ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

VOL. XLII. No. 9.

TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK 129, 143
Plate Connections for Cylinder Piers (illustrated).. 130
The Sag and Tension of Line Wire (illustrated).... 130
The Ventilation of Tunnels (illustrated)..... 131
Calculation of Cast-Iron Columns (illustrated)..... 134
A New Roller Grinding Mill (illustrated)..... 135
The Seavey Island Prison for Captive Spaniards.... 135
New Tunnels, Intake Crib and Pumping Stations, Chicago, Ill. (with two-page plate and other illustrations)..... 139
Smokeless Firing with Bituminous Coal on Passenger Locomotives 144
Freight Cars for the Imperial Chinese Rys. (illustrated) 144
EDITORIAL NOTES 136
Emergency Brakes for Electric Cars—The Ventilation of Tunnels—Paying for Water Used for Public Purposes—The Value of Reducing Curvature in Railway Location—The Boom in the Iron Market.
EDITORIAL:
The Breakage of Steel Rails 137
LETTERS TO THE EDITOR 138
Stream Pollution Fallacies—Concerning Roof Truss Design—Locking Bar Steel Pipe Lines—A 198-ft. Dive in Tacoma Harbor—Why Not Print Prices?—Elements of Design Favorable to the Speed Regulation of Plants Driven by Water—Notes and Queries.

THE DRAINAGE CANAL WATER POWER scheme at Chicago has again been postponed, the Trustees of the Drainage Canal having taken no action upon the bids received Aug. 23. Only two bids were received: Clarence Buckingham, $5 per HP. per year for a 50-year franchise; John Norton, President of the Economy Heat & Power Co., of Joliet, $4 per HP. per year for a 75-year or a 99-year franchise, or $25 per HP. per year for electric power delivered to the city, at the canal and Robey St. The amount of power to be developed is estimated at about 20,000 HP. The bids were referred to the Committee on Engineering, but the Trustees adopted resolutions instructing the committee to recommend no proposal which shall not be so modified as to contain certain clauses for the protection of the Sanitary District and the future interests of the federal government. These clauses are practically as follows:

(1). No hydraulic works shall be constructed which shall in any way interfere with the plans of the utilization of the drainage canal as a portion of a navigable waterway connecting the lakes with the Mississippi River.

(2). The Sanitary District or the federal government may be free to make any alterations in location or character of the hydraulic works, which may be found necessary for navigation purposes, on the payment of the actual expenses of such alterations or removal, and a reasonable compensation for loss of power during such time; and no vested rights shall accrue as against the plans of the federal government or the Sanitary District as to a navigable channel.

(3). At the expiration of ten years, or at the expiration of any period of ten years in the life of the water-power lease, the Sanitary District, or the City of Chicago, under authority of the Sanitary District, on one year's notice, may terminate the life of said lease to the extent of demanding and appropriating so much of said water power as may be necessary for municipal lighting of said City of Chicago on the payment of reasonable and appraised compensation for money invested and the improvements made.

A special committee of the Civic Federation has investigated the matter, with regard to the utilization of the power by the city. The permanent investment for developing 20,000 HP. is estimated at $2,700,000 ($1,200,000 for dams and works, $1,500,000 for plant), and the cost per HP. at the turbines is given as follows:

Interest on permanent invest. (4%)	$5.40
Operating expenses	4.00
Depreciation and repairs	2.85
	$12.25

This would be $15 per HP. delivered in Chicago, while the lowest cost which the City Electrician hopes to reach in developing electricity for street lighting by steam plant is claimed to be $30 per HP. for 10½ hours' service. According to these figures, if the city had the current from the water-power plant at $15 per HP. for 24 hours' service, it could sell power for manufacturing purposes for 13½ hours, and could also sell the surplus power. The city, however, has made no bid, and claims that there would only be power enough for street lighting.

THE SNOQUALMIE FALLS WATER POWER plant is 25 miles west of Seattle, Wash., 34½ miles northeast from Tacoma, and 34½ miles southeast from Everett. The depth of the falls is 270 ft., and the water for the power plant is carried in a 7½-ft. steel pipe down a shaft 10 × 27 ft., and 250 ft. deep. At the bottom is a chamber 40 × 30 ft., 200 ft. long, in which are placed the water wheels, supplied by a 10-ft. steel pipe along the roof of the chamber. From this chamber extends the inclined tail-race tunnel, 12 × 20 ft., 450 ft. long, the mouth of which is at one side of the base of the falls. There are four water wheels and four Westinghouse dynamos of 2,000 HP. each. Two aluminum tri-phase circuits extend to Seattle and two to Tacoma. There is a brick and iron transformer house at the falls, and two brick substations at Issaquah and Renton, 9 and 20 miles from the falls. At Renton the transmission lines diverge to the two cities. Seattle, 31 miles, has a stone and iron power house and office building, and Tacoma has a similar building of brick and iron. The minimum and maximum power of the river developed at the falls is 30,000 HP. and 1,500,000 HP. respectively, while by means of water storage a uniform power of 100,000 HP. can be obtained. The primary voltage is 1,000 volts, transformed up to 30,000 volts for transmission and down to 2,000 volts for distribution. The plant was established by the Snoqualmie Falls Power Co., of Seattle and Tacoma, of which Mr. Thomas T. Johnston is Chief Engineer. The water wheels are of a design invented by Mr. Johnston, and resemble in form the double impellers used for rotary blowers and pumps.

PROGRESS ON THE ASSOUAN DAM, on the Nile, is reported in "The Engineer" as obtained from Sir Benjamin Baker. On the Mahommed Ali Island portion of the dam 1,833 workmen are employed—1,572 being natives; and on the other portions 5,983, or 7,816 employed in all. Excavation in rock and soft material is being carried on in the navigation channel and at the site of the dam; 14,035 cu. m. of masonry have been built; work is in progress in closing certain channels; 466,000 bricks have been burned and 300,000 more are made, and much stone quarried and dressed. At the Assiout barrage 12,000 men have been employed; and an area of 13 acres has been uncovered by pumping; much of the masonry is also laid, and the total of concrete and brickwork done to July 31 was 37,347 cu. m. out of a total of 130,000 cu. m. The health of the men and staff is very satisfactory, as is the progress made this season.

THE RECENT CINCINNATI WATER CONTRACT award has been upheld in the court. A few weeks or months ago the Water-Works Commissioners awarded the contract for portions of the new works at California to a contractor who was $132,000 above the lowest bidder, on the ground that an investigation showed the lowest bidder proposed to use material the quality of which was inferior to that specified. It was urged that either the contract should have been given to the lowest bidder or new bids invited. In addition, the engineers were severely criticised, in and out of court, for taking steps which led the lowest bidder to request that he be allowed to withdraw his bid. The court justifies the action of the engineers.

A $2,500,000 BOND ISSUE FOR A WATER FILTRATION plant at Pittsburg and an extension of the meter system will be voted on at a popular election to be held on Sept. 19.

INFORMATION REGARDING THE ELECTROLYSIS of water mains, throughout the country, is being gathered by Mr. F. A. W. Davis, Vice-President of the Indianapolis Water Co., Indianapolis, Ind. Mr. Davis has prepared and sent out to water-works men a few questions asking for information on various phases of the subject. It is to be hoped that a large number of complete reports may be received by him.

A HEAVY RAINFALL IN THE VICINITY OF BOSTON occurred in the evening of Aug. 22. The gage at the Chestnut Hill reservoir showed a total fall of 2.33 ins. between 5:50 and 7:15 p. m., a maximum intensity of 4.5 ins. per hour and average rate of 1.65 ins. per hour during the 85 minutes named. We are indebted to Mr. Chas. W. Sherman, Jun. Am. Soc. C. E., Assistant Engineer, Metropolitan Water Board, for the above information.

THE MOST SERIOUS RAILWAY ACCIDENT of the week, and also the most curious one which we have recorded under this heading for some time, occurred at Milbury, Ohio, Aug. 22, on the Lake Shore & Michigan Southern R. R. The engine driver of a fast train, seeing an open switch before him, applied the brakes, reversed the engine and then jumped from the cab. He was instantly killed, and the fireman, who also jumped, was seriously injured. The switch was closed, however, by the attendant in the switch tower just in time to save the train.

THE STEEL ARCH ROOF of the Chicago "Coliseum" collapsed on Aug. 28, killing nine workmen and injuring 13 others. The "Coliseum" is a building designed for amusement and exhibition purposes, which was being constructed on the site of the old Libby Prison on Wabash Ave., in Chicago. It was 304×172 ft. in ground plan, and the main auditorium was covered by an arch roof carried by 12 three-hinged steel arches of 150-ft. span and 66½ ft. high at the center. At the time of the accident the roof arches had been erected and the workmen were at work riveting up the connections. The north end arch fell first, and the others fell in succession, overlapping each other like the fall of a row of bricks, until the last had fallen. About 35 workmen were at work on the building at the time of the accident, and the deaths and injuries noted above occurred among these men. No definite explanation is offered of the accident. The collapsed steel work was designed by Mr. E. C. Shankland, M. Am. Soc. C. E., of Chicago, and the contractors for the metalwork and erection were the Pittsburg Bridge Co., of Pittsburg, Pa. The building will be reconstructed. We shall give more complete details of the disaster in a future issue. In closing it may be noted that a precisely similar accident occurred to the original "Coliseum," of which the present building was the successor, during its erection in 1895 (Eng. News, Aug. 29, 1895, and Nov. 12, 1896).

Later press dispatches give the following statement concerning the accident, made by Mr. E. C. Shankland, the Chief Engineer:

Twelve arches, all the arches of the "Coliseum" under construction, were up, the last one being placed in position Saturday, and to-day (Aug. 28) the traveler was being taken down, the longitudinal purlins and the diagonal braces at the south end were in place, but none of the sub-purlins had been put in position, nor had the diagonal bracing between the two north arches been connected up. Had this been done before and had the traveler been taken down the accident would not have happened. The accidents is one that may always happen during the erection of the steel work and before all the roof purlins and roof bracing are in place. The hinged arch used in the "Coliseum" is the same as that used by the Pennsylvania R. R. in its stations at Jersey City, and Broad St., Philadelphia; by the Philadelphia & Reading R. R. in its Philadelphia station, and by me in the 1st Regiment armory, 16th St., and in the Manufactures and Liberal Arts Building at the World's Fair. It is commonly used in roof trusses of this and larger spans. The management has decided at once to replace the arches and proceed with the immediate completion of the building, and have it ready for the national convention next summer. The loss will not exceed $25,000. The worst feature of the accident was the loss of life.

A similar statement, made by Mr. D. W. Church, the Resident Engineer of the Pittsburg Bridge Co., is as follows:

We were riveting the last arch; it had been put up Saturday. The arches had been bolted and as they stood they were as secure as they would have been if riveted. As the bolts were removed rivets were put in their places. We were taking down the traveler, but that could not have been the cause of the disaster. There were 300 tons of material in the superstructure. Good material was used, and there was no penuriousness on the part of the company. When only a few arches had been put in place they stood one of the heaviest winds we have experienced in a year. We were not hoisting any iron at the time of the collapse, but we had been—in fact, we had been doing hoisting all the time. There had been no pulling on weights at an angle. It is possible for vibration to throw down a structure of this sort. It would be impossible to replace the material within six months.

In connection with the above statements we may note that we have been informed on known and reliable authority that the arches had no lateral bracing between them below the hip.

THE GOTKEIK VIADUCT, in Burmah, will be about 2,300 ft. long and 320 ft. high at the extreme point. As before stated, the Pennsylvania Steel Co. received the contract for its manufacture, in competition with English and European firms; and, on Aug. 23, Foreman Louis M. Gross and 25 American workmen sailed for Rangoon, Burmah, to erect this structure. The material itself is also on the way to Rangoon, and with it goes about 20 carloads of erection plant, including an air-compressor for riveting.

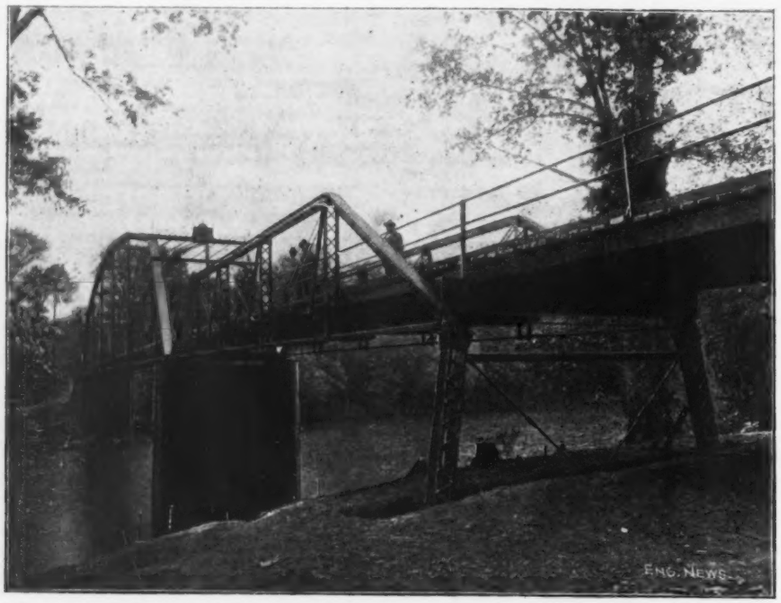
A BRIDGE ACROSS THE INDUS for the Kotri Rohri Section of the Indian State Railways is being constructed by the Thames Iron Works of England, which has just shipped the 5,000 tons of steel work in sections. The bridge consists of five spans 350 ft. long and one span 100 ft. long, carried on masonry piers. It will carry a single 5½-ft. gage railway track, and two outside sidewalks. The trusses are riveted, triangular trusses with bottom chords 4 ft. × 4½ ft., and top chords 4 × 4 ft.

A CONSOLIDATION LOCOMOTIVE of exceptional size is being built for the Illinois Central R. R. by the Rogers Locomotive Works, of Paterson, N. J. Its total weight will be 214,000 lbs., and the engine may well be compared with the list of large consolidation engines in our issue of July 27, 1899. The general dimensions, as furnished us by the builders, are as follows:

Driving wheels(cast-steel centers)	4 ft. 9 ins.
Truck wheels (steel tires)	2 " 9 "
Tender wheels (steel tires), Fox trucks	3 " 0 "
Wheelbase, driving	16 " 3 "
" total engine	24 " 5 "
Weight, on drivers	194,000 lbs.
" total engine	214,000 "
Cylinders	23 × 30 ins.
Boiler, diameter inside barrel	6 ft. 6 "
" barrel plates	⅞-in.
" working pressure	210 lbs.
Firebox (Belpaire)	11 ft. × 3 ft. 6 ins.
" side plates	⅜-in.
" crown plate	7-16-in.
" tube plate	⅝-in.
Tubes (iron): No. 417; diam.	2 ins.
" thickness	No. 11, B. W. G.
" length	13 ft. 0 ins.
Heating surface, tubes	2,951 sq. ft.
" " firebox	252 " "
" " total	3,203 " "
Grate area	38½ " "
Capacity of tender tank	5,000 gallons
Fuel	Bituminous coal.

PLATE CONNECTIONS FOR CYLINDER PIERS.

In bridging rivers in the Mississippi Valley it has become very common in recent years to use cylinder piers filled with concrete and connected by a solid web of steel plate. These cylinders can be readily sunk by inside dredging, and when filled with concrete are very stable. The web connection has the advantage over a system of bracing, which was formerly in common use, that the strain is distributed along the cylinder, instead of being concentrated at certain points, as would be the case were braces attached.



BRIDGE ACROSS THE OUACHITA RIVER, GARLAND CO., ARK., SHOWING CYLINDER PIERS WITH WEB CONNECTION.
The Groton Bridge & Manufacturing Co., Groton, N. Y., Builders.

We illustrate herewith a highway bridge with foundations of this type recently built over the Ouachita River, at Hot Springs, Garland Co., Ark., by the Groton Bridge & Manufacturing Co., of Groton, N. Y. The central span of this bridge is 219 ft. in length, and the end spans are 79 ft. The roadway is 16 ft. in the clear, and the central trusses are 34 ft. high at the center. The cylinders for the piers are each 5 ft. in diameter and 37 ft. in height, and the plates connecting them are 12 ft. 4 ins. in length. The connection of the plates to the cylinders is made by a pair of 3 × 2½ × ¼-in. angles, which are riveted to the cylinder at the bridge shop. The horizontal splices in the webbing between the cylinders are made with a 6 × ¼-in. plate and a pair of 3 × 2½ × ¼-in. angles. The circumferential joints of the cylinders have lap connections and the joints are calked from the water line down.

We are indebted to Mr. H. G. Dimon, Consulting Engineer of the Groton Bridge & Manufacturing Co., for the photograph from which our illustration is made and the information from which the above description is prepared.

THE SAG AND TENSION OF LINE WIRE.

By Cary T. Hutchinson, Ph. D., M. Am. Inst. Elec. E.*

The problem that presents itself in stringing line wire is to determine the sag or tension at which the wire should be strung at the prevailing temperature, so that the tension shall not exceed an assigned maximum at the minimum temperature.

The ordinary procedure is to assume a maximum tension and calculate the length of the arc; then to caluiate the length that the wire would have at the minimum temperature from the coefficient of expansion of the material with temperature, and with this new length to find the corresponding tension and sag; this process is repeated for each new temperature.

This procedure is used generally, the error made in not considering the elasticity of the wire not being recognized. The tables and formulae in various handbooks (e. g., Roebling's "Wire") are calculated on this false assumption.

The error is a very material one, as can easily be shown. The ordinary approximate equations for the span, i. e., the parabola equations assuming rigid supports, are as follows:

Let

p = unit tension in the wire at lowest point, in lbs. per sq. in.
a = cross-section of the wire in sq. ins.
P = total tension = a p.
D = weight, in lbs., of a rod 1 ft. long and 1 sq. in. cross section.
s = sag at center of span in ft.
L = distance between supports, in ft.
l = length of the arc, in ft.
γ = co-efficient of expansion per C°.
λ = co-efficient of elongation.
= 1/E (E is Young's modulus).
Q = breaking weight, lbs. per sq. in.
n = factory of safety.
T = temperature, C°.

Put p_0, L_0, etc., for initial condition, i. e., at temperature T_0, and let p l, etc., refer to quantities at temperature T, then

$$P = a\,p. \tag{1}$$

$$n\,p = Q. \tag{2}$$

The approximate equation for the suspension is,

$$p = \frac{L^2\,D}{8\,s}, \text{ or } s = \frac{L^2\,D}{8\,p}. \tag{3}$$

the length of the arc is,

$$l = L + \frac{L^3\,D^2}{24\,p^2}. \tag{4}$$

or,

$$l = L + \frac{8\,D^2}{3\,L}. \tag{5}$$

The length of any wire subject to a change both of temperature and tension is,

$$l = l_0\,[1 + \gamma w\,(T - T_0)]\,[1 + \lambda\,(p - p_0)]. \tag{6}$$

Put

$$T - T_0 = \triangle\ T; \quad p - p_0 = \triangle\ p.$$

Substituting from (4) in (6), and omitting a term of the order of 10^{-4} compared to unity,

$$\triangle T = \frac{L^2\,D^2}{24\,w\,Q^2}\,[n^2 - n_0^2] + \frac{\lambda\,Q}{\gamma w}\left\{\frac{1}{n_0} - \frac{1}{n}\right\}. \tag{7}$$

For an inelastic wire $\lambda = 0$, and (7) becomes

$$\triangle T = \frac{L^2\,D^2}{24\,\gamma w\,Q^2}\,[n^2 - n_0^2]. \tag{8}$$

(7) gives the relation between n and $\triangle$ T; (1), (2) and (3) then give the sag, s, for all values of n; hence the relations of p, s and T are known.

Equation (7) is of the third degree in n, and cannot be solved directly; the simplest method of solving it is to calculate values of $\triangle$ T for various values of n, and plot a curve suited to the conditions.

Note that this equation (7) gives the increment of temperature only, not the actual temperature; the initial factor of safety n_0 can then be applied to any initial temperature that may be chosen; the relation of equation (7) holds good for the changes in the factor of safety due to changes in the temperature and the dependent changes due to elasticity, starting from any assumed initial conditions.

Equation (7) can be simplified for purposes of computation, as follows:

Put

$$n = r\,n_0,$$

where r is the ratio of the factors of safety at the two temperatures,

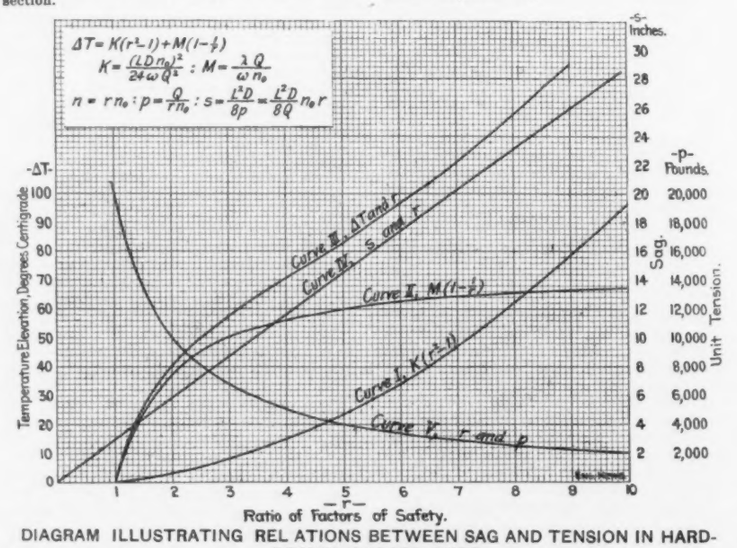


DIAGRAM ILLUSTRATING REL ATIONS BETWEEN SAG AND TENSION IN HARD-DRAWN COPPER WIRE.
Span, 100 ft. Factor of Safety at Initial Temperature, 3.

Then

$$\blacktriangle\ T = \frac{1}{24\,\gamma w}\left[\frac{L\,D\,n_0}{Q}\right]^2 (r^2 - 1) + \frac{\lambda\,Q}{\gamma w\,n_0}\left[1 - \frac{1}{r}\right]. \tag{10}$$

Putting

$$K = \frac{1}{24\,\gamma w}\left[\frac{L\,D\,n_0}{Q}\right]^2. \tag{11}$$

*71 Broadway, New York city.

and

$$M = \frac{\lambda Q}{\gamma\prime\ n_0}. \qquad (12)$$

$$\triangle T = K (r^3 - 1) + M \left[1 - \frac{1}{r}\right]. \qquad (13)$$

The values of the two functions

$$(r^3 - 1) \text{ and } \left[1 - \frac{1}{r}\right]$$

are given in the table; the constants K and M are then to be calculated for the material and conditions, and the curve plotted giving $\triangle$ T in terms of r, or of n.

For example, for hard-drawn copper,

$Q = 6 \times 10^4$; $\gamma\prime = 1.6 \times 10^{-8}$; $\lambda = 6 \times 10^{-6}$.
$D = 3.85$; these are the constants of the material.
Taking $L = 100$ ft. and $n_0 = 3$, thus assuming the elastic limit of hard-drawn copper to be 20,000 lbs.
$K = 9.72 \times 10^{-4}$.
$M = 7.5 \times 10$,

and

$$\triangle T = 0.972 [r^3 - 1] + 75 \left[1 - \frac{1}{r}\right]. \qquad (14)$$

This is the equation for hard-drawn copper for a span of 100 feet and maximum tension of 20,000 lbs. per sq. in., at any assumed minimum temperature.

The curve sheet below shows graphically the facts for hard-drawn copper under these conditions;

Curve I. shows the part of $\triangle$ T due to the coefficient of expansion, or is the term K $(r^3 - 1)$;

Curve II. is the term M $\left(1 - \frac{1}{r}\right)$ due to elasticity; Curve III. is the sum of these two, and shows the correct relation between $\triangle$T and r. Curve IV. shows the relation of r and s; Curve V., the relation of r and p.

A numerical example will show clearly the importance of the elasticity;

For a temperature rise of 40°.—

By correct Curve III.,

$r = 2$; $n = 6$; $p = 10{,}000$ lbs.; $s = 5.8''$.

By Curve I., neglecting elasticity,

$r = 6.5$; $n = 21.5$; $p = 3{,}100$ lbs.; $s = 18.6''$.

i. e., the tension calculated correctly is 3.23 times as great as when temperature alone is considered, and the sag correspondingly less.

The gist of this is that the wires can with equal safety be strung much tighter.

TABLE I.

(r).	$(r^3 - 1)$.	$(1 - 1/r)$.	(r).	$(r^3 - 1)$.	$(1 - 1/r)$.
1.0	0.0	0.0	0.50	19.25	0.778
1.25	.56	.200	.75	21.56	.789
1.50	.25	.333	5.0	24.00	.800
1.75	2.06	.429	.25	26.56	.810
2.0	3.00	.500	.50	29.25	.818
.25	4.06	.556	.75	32.06	.826
.50	5.25	.600	6.0	35.00	.833
.75	6.56	.636	.25	38.06	.840
3.0	8.00	.667	.50	41.25	.846
.25	9.56	.692	.75	44.56	.852
.50	11.25	.714	7.0	48.00	.857
.75	13.06	.732	.25	51.56	.862
4.0	15.00	.750	.50	55.25	.867
.25	17.06	.765			

THE VENTILATION OF TUNNELS.*

By Francis Fox, M. Inst. C. E.

The principle hitherto acted upon, where mechanical ventilation has been adopted for tunnels, has been to exhaust the vitiated air at a point midway between the portals of a tunnel, by means of a shaft with which is connected a ventilating fan of suitable power and dimensions. In the case of the tunnel under the River Mersey, such a shaft could not be provided, owing to the river being overhead, but a ventilating heading was driven from the middle of the river (at which point entry into the tunnel was effected) to each shore, where a fan, 40 ft. in diameter, was placed. By these means the vitiated air is drawn from the lowest point of the railway, and fresh air flows in at the stations on each side, to replenish the partial vacuum. In the Severn Tunnel, owing to the middle of the length of the tunnel being nearly at the Gloucestershire side of the river, a vertical shaft is sunk to the tunnel, and a fan, 45 ft. in diameter, extracts the vitiated air at this point.

Objection has been taken to this system of placing fans midway between the entrances of a tunnel, as being liable to be affected by a strong wind blowing in at either end. There is some ground for this contention, but the late Mr. Harrison Hayter stated to the recent Departmental Committee of the Board of Trade that the only difference he observed was that the speed of the air traveling to the fan was about 1 mile per hour less in one direction than in the other. It may also be noticed that when a strong wind is blowing into a tunnel, no artificial ventilation is required, and the fan may be stopped with advantage. It is when the air in the tunnel is stagnant, or is moving very slowly, that mechanical aid is required, and a fan of suitable size and power effectually accomplishes the result desired. The author has by inquiry and by personal experience ascertained that if the amount of carbon dioxide can be kept low, so as not to exceed 20 parts in 10,000, the air in a tunnel is satisfactory.

The consumption of coal by a locomotive during the passige through a tunnel having been ascertained, allowing 29 cu. ft. of poisonous gas for each pound of coal consumed, the volume of fresh air required to maintain the atmosphere of the tunnel at the above-mentioned standard of purity is ascertained as follows: The number of lbs. of fuel consumed per mile, multiplied by 29, multiplied by 500, and divided by the number of minutes' interval between the trains, will give the volume of air in cubic feet which must be introduced into the tunnel per minute to maintain it in a sufficiently pure state to avoid inconvenience.

As an illustration, assume that the tunnel is 1 mile in length, and the consumption of fuel is 32 lbs. per mile, and that one train passes through the tunnel every five minutes in each direction, the volume of air required per minute will be:

$$\frac{32 \text{ lbs.} \times 29 \text{ cu. ft.} \times 500}{2\frac{1}{2} \text{ minutes}} = 185{,}600 \text{ cu. ft.};$$

the air will then be maintained at a standard of purity in which the carbon dioxide does not exceed 20 parts in 10,000.

This is the basis upon which the Mersey and the Severn Tunnels are ventilated, and which have been shown, by the Report of the Committee referred to, to be efficiently supplied with fresh air; it is, however, to be regretted that, in the case of the Mersey Tunnel, owing to the impecuniosity of the Company, inferior coal is now used, and the fans are driven at a lower speed than was intended. The airways then become encrusted with soot, which in some places is between 2 ins. and 3 ins. in depth; but, notwithstanding these drawbacks, the examination of the air of the tunnel, made by Dr. John Haldane, F. R. S., for the Departmental Committee, showed that the amount of carbon dioxide was considerably less than 20 parts in 10,000. There is no doubt that this tunnel, when proper coal is used and the fans are run at the intended speed, is the most perfectly ventilated tunnel of its kind in the world.

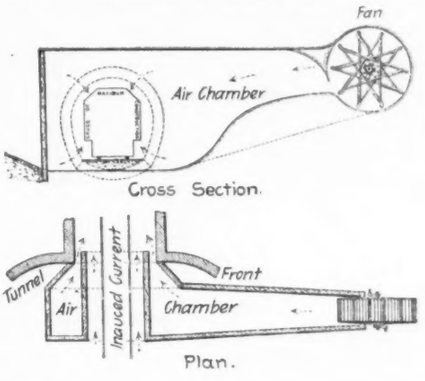
With the Metropolitan Railway the author does not intend to deal, as it has been the subject of recent investigation. The amount of carbon dioxide is, however, very high, reaching simetimes as much as 86 parts in 10,000. It is, however, only fair to point out that fan ventilation on that railway has never been practically adopted, the fans which were fixed being of insufficient size and power to produce any important effect on the air of the tunnel.

The Mount Cenis Tunnel is about 8¼ miles in length and 26 ft. in width, and, in consequence of the mountain above it, possesses no shaft. The construction is of excellent character, the tunnel being lined throughout with masonry or brickwork, except two lengths of 330 ft. and 260 ft., respectively. In these two lengths solid white quartz was encountered, which occupied years to penetrate. Owing to an alteration during construction, on the Italian side, the Bardonecchia entrance is at a considerably lower level than that originally intended, necessitating the introduction of an ascending gradient of 1 in 40 for a length of about 1,000 yds. from the portal. The tunnel is then nearly level for about 3½ miles, when a descending gradient of about 1 in 40 occurs for nearly 4 miles towards the French side. The higher altitude of the middle of the tunnel above its entrances has compromised its ventilation, and sometimes great difficulty is experienced in carrying on the traffic. At the Bardonecchia entrance there is a somewhat obsolete installation of seven oversbot water-wheels, 5 meters in diameter, and 6 meters in length on the breast, over which in succession a mountain stream is conducted. These wheels work air-compressors, the air being delivered under a pressure between 4½ and 6 atmospheres, and discharged at points 1 kilometer apart throughout the tunnel. The quantity of air is so small that for purposes of tunnel ventilation it has little effect, amounting only to 70 cu. ms. per minute of air at 75 lbs. pressure per sq. in.; but it is of great advantage to the men employed in the tunnel. At intervals of 1 kilometer there are refuges for the men, supplied with fresh air, water and a telephone. Into these chambers the men can retire when the smoke is thick, and there wait for an engine to take them out. The corrosion of rails is very rapid, and, were proper ventilation provided, it would not only be of the greatest comfort to the men, but the life of rails would probably be doubled. About 300 tons of rails have to be relaid every year, so that, were their life doubled, a saving of 150 tons would be effected annually, which would probably far more than pay for efficient ventilation. The author is informed that a preservative against rust is now being used, but with what result he is not aware. The temperature of the middle of the tunnel remains nearly constant during summer and winter, and is about 66° to 68° F.

The St. Gothard Tunnel is 9½ miles in length, and 26 ft. in width; it is nearly level from end to end, the gradient being only that needed for drainage purposes. The ventilation was entirely natural until recently; but, owing to the use of briquette fuel, with its dense smoke, and to the constant increase of the traffic, a time arrived when it was necessary that something should be done, and recently the Saccardo system has been adopted.

In long tunnels on steep gradients, such as exist in Italy and elsewhere, artificial ventilation is imperatively needed. In the cases of the Pracchia Tunnel, 3,000 yards in length on a gradient of 1 in 40; the Mount Cenis Tunnel, with its peculiar longitudinal section, described above, with gradients of 1 in 40 at both ends; the spiral tunnels, with gradients of 1 in 40, on the St. Gothard route, and the long tunnel of Ponte Decimo near Genoa—grave inconvenience and even worse results arise. Asphyxiation is not unknown, and the loss of life attending the collision of the 11th August, 1898, at the mouth of the last-named tunnel, in which twelve persons were killed and forty injured, wes the direct result of bad air.

The case of the Pracchia tunnel is interesting. It is one of fifty-two tunnels on the main line between Florence and Bologna, built by the late Mr. Thomas Brassey, Assoc. Inst. C. E. These are single-line tunnels, on a graident of 1 in 40. The traffic has increased greatly and has to be worked by heavy locomotives. Under any condition of wind, the state of this tunnel, about 3,000 yards in length, is bad; but when the wind is blowing in at the lower end at the same time as a heavy goods or passenger train is ascending the gradient, an almost insupportable state of affairs is produced. The engines, which are working with the regulators full open, often emit a large quantity both of smoke and steam, which travels concurrently with the train. The locomotives weigh 55 tons without tender. They have eight wheels coupled, with a tractive force of 15,400 lbs. The goods trains carry 250 tons of load and have an engine in front and one at the rear of the train; and when, from the humidity in the tunnels due to the steam, the wheels slip and possibly the train stops, the condition of the air is indescribable. A heavy train with two engines, conveying a Royal party and their suite, arrived on one occasion at the upper exit of the Pracchia Tunnel with both enginemen and both firemen insensible; and on another occasion, when a heavy passenger train came to a stop in the tunnel, all the occupants were seriously affected. On the occasion of the author's visit to the tunnel, on the 25th July, 1894, one of the brakesmen complained of being ill and of having fallen from his seat in one of the shorter tunnels.



The Saccardo system of ventilation has just been applied to the Pracchia Tunnel with remarkable results. Mr. Marco Saccardo, the well-known Italian engineer, avails himself of the annular space between the interior surface of the tunnel and the gage of maximum construction, and, upon the principle of the injector, blows, by means of a fan, a large volume of air into the tunnel at its mouth. This induces a strong inward current at the central opening, through which the trains pass. The Saccardo system of ventilation is illustrated in the cut, representing its application to a single-line tunnel. The tunnel is extended for about 15 or 20 ft. by a structure either of timber or brickwork, the inside line of which represents the line of maximum construction, and this is allowed to project for about 3 ft. into the tunnel. The space between this line and the exterior constitutes the chamber into which air is blown by means of a fan. Considering that the Pracchia Tunnel is 3,000 yards in length, the author had first thought there might be some tendency for the air to return through the open mouth, but nothing of the kind happened. The author believes this is one of the greatest advances that has been made in the ventilation of tunnels within memory. It can be added at a minimum of expense to any tunnel. The author measured the volume and temperature of air with the following result: Before starting the fan, the tunnel was filled with

*Condensed from a paper read before the Institution of Civil Engineers.

dense smoke from end to end, the temperature being 107° F., with 97° of moisture, or nearly complete saturation. With the fan running, the thermometer indicated 80° (the temperature of the external air), or a fall of 27°, the moisture was normal, and the amount of air propelled by the fan was 164,000 cu. ft. per minute, that by the induced current being 46,000 cu. ft., making a total of 210,000 cu. ft. of air per minute passing through the tunnel. The air is blown in at the upper end, and down the incline, the object being that an ascending train with its heavy trail of smoke and steam may be freed at the earliest possible moment from the products of combustion. These results are remarkable, and the air of the tunnel is cool and fresh. This system, however, cannot be applied to railways in which underground stations exist, as the effect of the current would be to blow the smoke to the platforms of the next station, the very part of the railway which should be kept in the best condition.

The Simplon Tunnel, now under construction, will be 12¼ miles in length, and will consist of two parallel tunnels, at a distance of about 50 ft. apart from center to center. The gradient from Brigue is only 1 in 500, and this for drainage purposes for a distance of 6¼ miles; thence the rails will fall on a gradient of 1 in 142 for the remaining 6 miles to the Italian portal. The ventilation of this tunnel has been very carefully considered, and although it is not definitely decided which system is to be adopted, it is not improbable that the Saccardo system will be selected, as in those cases where shafts are not available, it is the only one that can be advantageously employed. Even where shafts exist, and there are not intermediate stations, it is probably the most effective and economical method.

In the near future it is not improbable that the traffic in many tunnels, with frequent train service, will be worked electrically, in which cases the problem will be greatly simplified. Several tunnels on English railways stand in great need of improvement, such, for instance, as that under Sydenham Hill, on the London, Chatham & Dover, and that at Sevenoaks, on the South Eastern Railway.

The author desires to call particular attention to the need which exists in many tunnels during construction of a sufficient and even bountiful supply of fresh air to the workmen. With it they work with far greater comfort and vigor; without it the work progresses far less rapidly, at greater cost to both the company and the contractor, and with lasting injury to the men.

As regards work under compressed air, attention has been on several occasions directed at the Institution to the still greater need of ample air beyond the air-lock, to secure immunity from the various symptons ordinarily developed by compressed-air work. With air under pressure, on entering the lock, the air is absorbed by the blood, carrying with it any gaseous impurities in its constitution; and, consequently, if it is at all high in carbonic-acid gas, the blood receives that impurity. In coming out of the compressed air, as is well known, it is of great importance to be locked out slowly. The physiological reason for this may be illustrated by the difference between opening a bottle of soda water rapidly, by taking the cork straight out, or letting the pressure off slowly at the mouth of the bottle. If it be let off slowly, the gas escapes almost imperceptibly, whereas if the cork is taken out rapidly, the gas is evolved in large bubbles at once. It is well known that blood in the presence of air tends at once to coagulate, and recent investigations of certain cases which occurred in the deep sinking of cylinders at Newcastle and elsewhere show that when the pressure is taken off, and the globules of air are formed, the tendency is for the blood to coagulate. Where deaths have occurred, and post-mortem examinations have been made, the veins and arteries have been found filled with coagulated blood, consequently producing death. If the pressure be allowed to pass away slowly, this risk is reduced; the danger lies in the possibility of the formation of a clot in the system.

Discussion.

Mr. E. W. Moir had discovered in the Hudson and Blackwall tunnels the real meaning of ventilation, as he had had the misfortune to see a man's veins opened when he was just dying and had helped to squeeze the coagulated blood out of his system. There seemed a great difference of opinion as to what was ample ventilation, and there was a still greater variance in dealing with compressed air. It would take 30 parts of carbonic acid per 1,000 by volume to put out a candle in an ordinary heading. He had been in an atmosphere in ordinary tunnels when a candle would not burn, and no visible ill-effect was apparent on the men working in that high percentage. The carbonic acid seemed simply a measure of the impurities, and not in itself seriously detrimental even in such large quantities. When, however, compressed air was dealt with, it was very different. If the working pressure was above 20 lbs. per sq. in., any percentage which rose above 1 to 1¼ parts per 1,000 was almost sure to make itself felt on some men, and might be very serious in its results. At the Blackwall Tunnel and at the Hudson Tunnel it was found necessary, in order to keep the air at the right degree of purity—that was, at about 1 to 1¼ parts per 1,000—to analyse it regularly. The provision of a constant volume per man, as gaged by the revolutions of the engine, was useless, for it was once found that the air was very impure, even when 6,000 to 8,000 cu. ft. were being delivered. This case he remembered occurred when the Blackwall Tunnel was passing under the old Isle of Dogs sewer. It was, therefore, absolutely necessary to give a varying supply, according to the analyses in compresser-air works, and the limit should be about 1 to 1¼ parts per 1,000. An ample allowance in ordinary works, and a liberal one, he considered to be between 3,000 and 4,000 cu. ft. per man per hour, and even less would do at pressures below 30 lbs. per sq. in. He was much surprised to find recently that one of his expert divers now at work was quite content with only 250 cu. ft. per hour. The only excuse for his being alive at all, he supposed, was that, being a diver, he was naturally a selected man, and his hours were very short under water; consequently it did not do him very much harm. He had examined a diving-bell plant by one of the prominent diving-plant makers, where an allowance of 1,300 ft. was given. It would be seen that the figures varied widely. In undertakings where compressed air had to be used the fair and proper allowance had become a very serious question. He had framed a tender recently for a compressed-air work, where, from humanitarian reasons, the amount was fixed very high—namely, at 8,000 cu. ft. per man per hour. To compress that air required a great deal of power, and the cost amounted to considerably more than the men's wages who were going to consume it. Whether their competitors had looked much into that or not he did not know, but they were not the lowest, and he thought that may have accounted for it.

Mr. C. A. W. Pownall remarked that, in the case of the Usui Railway in Japan, there was a gradient of 1 in 15, and, therefore, the tunnels were at a very high inclination, resembling chmineys. In a space of 5 miles there were no less than 26 tunnels, the longest of which was 600 yds. The line had been laid out against his reports to the Japanese Government; but although he objected to the system on various other grounds, he confessed that the difficulty likely to arise with ventilation was not present to his mind. But when the locomotives began running, the difficulty with the smoke was found to be very great. When the engines were put to work, the difficulty of keeping steam was very great, and the fires were forced to the utmost; consequently, instead of a coal consumption of 32 lbs. per mile, which Mr. Fox assumed, the coal consumption, in trials which he had to conduct for the government, was no less than 250 lbs. per mile on an average, and in one case it was as much as 268 lbs. The smoke was so thick that it was impossible to see the man standing beside him on the footplate, and they were all nearly smothered. On the day before the trial began, when the steam gave out and the engine stopped in one of the tunnels, and remained there for 10 minutes, the driver was almost choked, and the natives lay face down on the ballast to breathe. That bore out the author's remarks in the Paper about what had happened in Italy, when the drivers were almost reduced to insensibility. In the 600-yd. tunnel in Japan, there were two sharp reverse curves, and consequently the smoke had to turn the corner to escape. The speed of the train was only 5 miles an hour, so that the smoke kept pace with it. Various schemes were proposed for remedying the nuisance. The Saccardo system, which the author had described, was not known at that time, and, no doubt, it would be an admirable method, because it would keep the smoke from following and smothering the train and driver. As it was, the very primitive method was adopted of hanging a curtain at the lower entrance of the tunnel, and closing it as soon as the train had passed in. That stopped the draft of air following the train, and enabled the train in some degree to liberate itself at it passed up.

Mr. J. C. Inglis thought that the question of ventilation of tunnels was a matter of degree. In tunnels, where the ventilation had been provided for on an elaborate scale, it was well known that the provision for ventilation applied for a certain service, and when that service increased it might become altogether inadequate. In the Severn Tunnel, for traffic up to a certain limit, say trains passing every 20 minutes or even 15 minutes, the ventilation was all that could be desired. In damp weather a vast change occurred in the conditions of the tunnel, so great, that, while satisfactory results were obtained under normal conditions, in unsatisfactory conditions it was admitted that the results might be very much improved. The Severn Tunnel was ventilated by means of an exhaust, much in the same way as the Mersey Tunnel. If the traffic in the Severn Tunnel became much more intense than it was at present, it would be difficult to decide what would be the necessary steps to improve the ventilation. In an instance where natural ventilation was depended on, namely, the Box Tunnel, on the Great Western Ry., which was 1 mile 66 chains in length with five shafts, part of the difficulty in the ventilation was that several of the five shafts acted at times in a manner prejudicial to the efficient ventilation of the tunnel. The tunnel was on a rising gradient of 1 in 100, and the section of the ground rose abruptly at each end. With a westerly breeze, as the tunnel lay east and west, the most advantageous conditions of ventilation held, but when the wind was exceedingly slight, at times shafts Nos. 1 and 2 acted as intakes and so diverted the rising or westerly current of air through the tunnel. This had been complained of by the men many times, as delaying the speedy clearing of the tunnel of steam. Again, assuming shafts Nos. 1 and 2 were not acting as down drafts, but were either up or neutral drafts, shaft No. 4 must frequently draw up more strongly than any of the others, and so abstracted the westerly current as well as the steam hanging in the tunnel, and what did not escape through shaft No. 4 found its way to shaft No. 5, with the result that the easternmost 48 chains of the tunnel was left unventilated, and in this length this steam, due to the passage of trains through it, hung to an inconvenient extent at certain times. He had looked through this tunnel from end to end, and it had been perfectly clear; but he had known cases in continuously dull weather when the men not only could hardly do any work for a week, or see 2 yards in front of them, but had to come out to the mouth every hour to get fresh air. Another point was the question of the corrosion of rails in tunnels; the author, however, did not give any idea of what it meant. He believed that the ventilation of railway tunnels was not a matter seriously affecting passengers, drivers or guards of the trains; but that the real pressure came from the permanent-way men who had to live in the tunnel, and from the excessive cost of the maintenance of the permanent way in tunnels by imperfect ventilation. He had had to relay a great part of the Box Tunnel after the rails had been in an exceedingly short time; and before such an operation could be undertaken the whole circumstances had to be carefully examined. From recent examination he had found a maximum corrosion and wear—because rails wore so much more quickly in a tunnel than in the open air. Particulars of the wear of the rails in the Box and Severn Tunnels, as compared with rails at either end, were shown in the following statement:

Box Tunnel (1 Mile 66 Chains in Length).
Percentage of Wear per Annum.

	Per cent.	Lbs. per yd. per annum.
Down line, gradient falling 1 in 100—		
At east mouth	0.439	= 0.377
28 chains from east mouth	1.800	= 1.540
48 " " " "	2.110	= 1.810
1 mile 8 chains from east mouth	2.880	= 2.480
At west mouth	0.640	= 0.555
Up line, gradient rising 1 in 100—		
At east mouth	0.620	= 0.575
1 mile 8 chains from east mouth	1.500	= 1.380
1 " 28 " " " "	1.520	= 1.310
At west mouth	0.680	= 0.587

Severn Tunnel (4 Miles 28½ Chains in Length).
Percentage of Wear per Annum.

	Per cent.	Lbs. per yd. per annum.
Down line, outside and quite clear of tunnel, Bristol end, gradient falling 1 in 100	0.280	= 0.240
Up line, outside and quite clear of tunnel, Newport end, gradient rising 1 in 100	0.440	= 0.380
At Bristol mouth, gradient falling 1 in 10	1.200	= 1.020
33 chains from Bristol mouth, gradient falling 1 in 100	2.160	= 1.860
3 miles 75½ chains from Bristol mouth, gradient rising 1 in 90	1.900	= 1.630
At Newport mouth	0.310	= 0.270
Down and up line under main-shaft level.	3.200	= 2.750

It would be seen that the maximum wear and corrosion together amounted to the extraordinary weight of 2½ lbs. per yard per rail per annum. Such a statement was a very serious one and involved a great expenditure. The wear was found over the whole of the rail, but the top, over which the engine and train passed, wore at a greater rate, he presumed, on account of the surface being kept bright and the gases being able to operate on it. But the rails also wore all round. The Great Western Co. tried to overcome that difficulty by boxing up the rails. He tried such experiments in the Severn Tunnel, and boxed up the rails so that the ballast approached the surface of the rails within 1 in. or 1½ ins., but it was found that—in the case, at any rate, of the limestone ballast—the cure was almost worse than the disease. There was a maximum wear of 2½ lbs. and an average wear of nearly 2 lbs. per yard per year. The average on the open line might be about 0.25-lb. in the same time.

Sir Benjamin Baker observed that Mr. Inglis, as Chief Engineer of the Great Western Ry., had introduced two very important practical points into the discussion. One was the abnormal wear of rails in tunnels, which had been exercising the attention of engineers not only in the Severn Tunnel, but in all the Alpine tunnels, and in every important tunnel throughout the world. The rapidity with which the rails wore out in tunnels, owing to bad ventilation, was extraordinary. In many cases a special section of rail had been introduced. It was not merely the rapid wear, and therefore the increased cost of maintenance, but it was also that for some reason or another, either a mechanical or chemical reason—mechanical in the sense of rusting causing an incipient crack, or chemical for some reason which was not quite clear—there was certainly a much larger percentage of breakages of rails in tunnels than at other parts of a line. Another point which Mr. Inglis referred to was that in ordinary tunnels—and by ordinary tunnels he included Alpine tunnels, but not such tunnels as the Metropolitan or the City & South London Ry.—the public were very little concerned. It was, as Mr.

Inglis said, the permanent-way men who were interested in the ventilation of tunnels. If there were good carriages, such as were customary on continental railways, with the windows fairly tight-fitting in order to keep up the temperature in the winter, there was no Alpine tunnel or any other tunnel in the world which was so long that the fresh air locked up in a carriage was not ample to see the passenger through that tunnel, however full of bad air that tunnel might be. He quite agreed with the author that 1,200 cu. ft. per hour was the sort of thing to be aimed at in schools and dwellings, and other places where people had to remain a long time. Even more than that—Mr. Moir had said 3,000 cu. ft.—was still more desirable in work under compressed air. But if engineers attempted to give 1,200 cu. ft. an hour in all cases, an enormous number of people would be killed. Supposing that were attempted to be done in a railway compartment in which people were traveling, in very cold weather, with the thermometer far below zero, in Russia or on the Canadian Pacific, everybody would be frost-bitten or die of pneumonia. There was no existing means in a railway carriage of heating anything like 1,200 cu. ft. per hour in cold weather, and in a country where the temperature fell below zero it was practically impossible. In steamships and still more in sailing vessels doing the North Atlantic passage, there were no means of heating that quantity of air, and to force down 1,200 ft., and restrict the proportion of carbonic dioxide to 9 parts in 10,000, would be to freeze passengers to death. Fifteen or twenty years ago the Americans, who were not entirely behind the age at any time, were investigating that question of ventilation on railways, and they thought if they wanted to look for impure air, requiring improvement in the interests of the general public, they would not look into tunnels, but into the railway carriages. They found that by no appliance of heating which existed on the American lines could they venture in winter to put in more than about 300 cu. ft. an hour per passenger; and that was about the best they could hope to do, and it meant about 24 parts per 10,000 of carbonic dioxide. He should be very sorry to make an official estimate of what the proportion would be found to be, if the coming Christmas happened to be a cold one, in a crowded third-class compartment in a train going to Scotland, where the train ran every 2 hours without stopping and the windows were all closed, and, if there happened to be any sleet and snow, almost every crevice was frozen up. There would be at least eight people in the compartment, and about 47 cu. ft. of air per passenger locked up in that compartment, and the door would not be opened for 2 hours, and he thought he might venture to say that the windows would not be opened either. Supposing that even the amount of air that leaked in during those 2 hours through the frozen-up crevices would supply the passengers with sufficient fresh air for ¾ hour out of the 2 hours, that would leave 1¼ hours to consume the air which was locked up in that compartment, that was, 47 cu. ft. per individual, and that would give 29 cu. ft. per hour, instead of 1,200 cu. ft., and 210 parts of carbonic dioxide per 10,000 at the usual rate of production, though probably considerably less with the people in a sleepy condition. It must not be supposed, from the remarks he had made, that he differed in any way from the general conclusions of the author, that the aim of engineers and architects should be to get as much circulation of air as was reasonably possible. But they could not accept any hard and fast rule that there must be 1,200 cu. ft., or 300 cu. ft., or 30 ft. All the circumstances of the case would have to be taken into account, and their own opinion as engineers obtained, as to what could be done in the particular circumstances that had to be dealt with.

Sir A. R. Binnie thought it might be interesting to place before the members an instance of a tunnel in which the circumstances of ventilation were in no way complicated with those of combustion. When the Blackwall Tunnel, which had two descending gradients and a level of 1,200 ft. under the river, was being designed, it became a very important question to decide how the ventilation in such a tunnel should be carried on, and somewhat elaborate arrangements were provided, in case they became necessary, for the exhaustion of the air. He was happy to say that those arrangements for exhaustion had never become necessary up to the present time. But, in order to endeavor to study the question from a more exact point of view than that of personal observation, at the very earliest period after the work was opened a series of meteorological observations of the air and the water in the river were established on the Middlesex side of the river, and maximum and minimum thermometers were established in the tunnel for the purpose of taking the temperature of the tunnel, as well as daily observations of the velocity of the air passing through the tunnel. He would endeavor to give the general results of the observations, which had now extended over something like 18 months, and were carefully recorded twice a day. It was found that, as compared with the temperature of the air above ground, the average temperature of the air in the tunnel was between 4° and 5° lower; this, however, varied. For instance, in last September, during the very hot weather which was then experienced, it was found that the temperature of the air rose 20° or 22° above that of the tunnel. The temperature of the tunnel was highest in the middle portion under the river, where the temperature was between 2° and 2½° lower than the air above. The temperature of the river water was generally 5° or 6° lower than the temperature of the air above it, so that the temperature of the air in the tunnel was between 9° and 11° lower than the temperature of the water in the river. It was found as a result that, taking the average of the whole 18 months, the velocity of the air in the tunnel ranged from 45 ft. to 50 ft. per minute; it was sometimes a little less. It fell to about 30 ft. in dull and humid days and rose sometimes to a considerable breeze; in fact, so much so that those people who rode on the tops of omnibuses complained of it as being exceedingly chilly and likely to cause cold. As to the direction of the air in the tunnel, there were two shafts on the Middlesex side and two on the Kent or southern side of the river. In the case of the up-cast shaft (No. 3), which had a long ventilating column, the up-cast was almost continuous, but in all the other three cases it was exceedingly difficult to lay down any exact rule. The currents of air were exceedingly difficult to study. It would be remembered that the direction of the tunnel was generally north and south, and it only happened that when the wind was blowing either from the north or south that a complete draft through the whole length of the tunnel was obtained.

Mr. W. R. Galbraith remarked, in reference to the necessity of ventilating the deep-level tunnels of underground railways, that he had had 3 or 4 months' experience of the working of the Waterloo & City Ry., the length of which between the openings—there was no opening between Waterloo and the terminal station at the Mansion House—was about 1 mile and 3 furlongs. The result of the working had shown that the air was perfectly pure, and there was no disagreeable smell. When he first went through the tunnel of the City & South London Ry. he noticed a damp smell, but that was not found in the Waterloo & City Ry. He did not know the reason, or whether the greater diameter of the tubes, which were 12 ft. as against 10 ft., had anything to do with it, but the air was very good indeed in the Waterloo & City Ry., not only during the time the trains were running, but at night when the traffic had ceased. There seemed to be a draft right through the tunnels, a distance of 2,500 yards. If the conditions in the railway continued as at present it would be a waste of money to think of introducing fans. He believed that the facts that have given rise to comment were, that on the day the Guards arrived in London from Khartoum a great number of people assembled at Waterloo, and after the Guards had marched out of the station there was an immediate rush for the electric train. The trains were supposed to carry about 200 people, but there was such a great crush that 600 people crowded into the train. The result was that for some reason or other there was not sufficient power—electricity was still in an experimental state on the Waterloo & City Ry.—and the train stuck in the tunnel. The people confined in the carriages with all the windows shut found that the air became stuffy, as might easily be imagined. He need hardly say that the air even in a London omnibus with sixty people in it, and all the windows shut, would not be very good. There was a great outcry that the air in the Waterloo & City line was very bad; but there was a perfect draft through the tunnels and the passengers had not found any inconvenience whatever.

Mr. E. Wragge desired to describe his experience in connection with the St. Clair Tunnel on the Grand Trunk Ry., which connected that portion of the Grand Trunk Ry. which was in Canada with Michigan. The tunnel was a tubular, 20 ft. in diameter, and 2,000 yards long, and contained a single line. When the line was first opened large ten-wheel engines, weighing 200,000 lbs., were used, which were expected to take the same load up the gradient of 1 in 50 as were taken by smaller engines over the other portion of the line on easier gradients. It was found, however, that in taking those loads the links and pins which came from nearly every railway in the country, were not all of them of sufficient strength to stand the jerk which came upon them when the gradient changed at the bottom from the level portion to the 1 in 50, and frequently the links broke and the train stopped in the tunnel. In almost every instance when that occurred some train-man, who had been left in the tunnel to look after the portion that was left behind, became insensible, and he believed two of the men had died. The engines did not burn bituminous coal, but anthracite, in which there was very little smoke. The heavier trains had to be abandoned entirely, and a smaller train taken through which could go through without any stoppage. A great number of the trains that came through were goods trains, and arrangements were made by which those trains were bunched and ran very closely one after the other. In that way the current of air was kept running in one direction for a long time, and after that no further accidents occurred.

Mr. J. R. Bell said that on the Indian frontier steep tunnels descending through the rims of elevated plateaux tended to act not unlike the natural passes which were but notches in those rims, hot air ascending in the heat of the day and cold pouring outwards in a stream at night. Forcing cooled air down hill was seemingly not only the desideratum but the easier operation. The Indian Government had had occasion to study such questions in the interests of the frontier railways. Its most notable work of this class, the Khojuk Tunnel, was some 3 miles long, and was originally divided by two shafts into three lengths. From near mid length one end falls 1-40 and the other 1-1,000, so that between the two shafts there lay, as it were, a pocket of dead air. There the ventilation had been much improved by closing both shafts, and it was not thought necessary to do anything in the direction of artificial ventilation. Another tunnel, which, but for the danger of falling boulders, might be opened out, was drained by side adits some 100 yards apart, but these failed to keep the air on the footplate breathable and oblique blow-holes had to be made. This tunnel was halfway up a 1-40 bank of some miles in length. It was only worked in daylight, i. e., when the air-flow ran usually uphill. The only troublesome cases in India were tunnels at elevations of 3,000 to 5,000 ft. above sea-level. So far the advice tendered to the Government of India as to tunnel ventilation was mainly of a negative character and might be summarized as follows: "Fan installations were not yet necessary. Having adopted the vacuum brake, supplying the engine-crews with air compressed outside was infeasible. Breathing masks fed by pipes with air from the front buffer beam were of little use when the wind was with the train. On new lines tunnels should be flatter than the ruling gradient outside. The roomy engine-and-tender cabs should be closely curtained at sides and back with wetted canvas in tunnel sections. Welsh coal alone should be used on certain sections with troop-traffic." Those, till quite lately, were the leading recommendations.

Mr. A. Schrafl, of Lucerne, stated that in the autumn the St. Gothard Tunnel was traversed daily by 10 fast through trains, 8 omnibus trains, 16 regular and 27 optional goods trains, in all 61. The first passed through in 15 minutes, the omnibus trains in 22 minutes, and the goods trains in 28 minutes. The use of briquettes was confined to the locomotives of fast through trains, all the others burnt coal. At the center of the tunnel the minimum temperature of the year varied between 14.5° and 16.4° C., and the maximum temperature between 22.4° and 23.4° C. It was not so much the combustion of the briquettes as the rapid succession of trains, combined with the momentary equilibrium of barometric pressure between the ends of the tunnel, which caused the accumulation of thick smoke, and the shutting in of the noxious gases in intolerable quantity. The passengers and the personnel of the engines and trains were, however, not so much affected as those engaged upon the repair of the tunnel and the surface men. It would be impossible to construct air-shafts. During the course of 1898 the installation had been undertaken at the north end of plant upon the Saccardo system. The works consisted essentially of two ventilators, 4.9 meters in exterior diameter, with an annular air-chamber in the interior of the tunnel, all the passages for the junction being in masonry. The apparatus would at first be driven by a steam-engine of 450 HP. With such arrangements it was proposed to drive into the tunnel 126 cu. m. of fresh air per second, and to produce in it a current of 3 m. per second in the direction of north to south, when the natural current in that direction, or vice versa, did not move at that or a greater speed. When this result was once obtained, not only could the survey and the repair of the permanent way and the masonry of the tunnel be carried out in pure air, but a considerable diminution of the wear of the metallic parts of the structure was expected; it was now six times as great as on the open sections of the line. It was presumed also that the ventilation would reduce the time during which the products of combustion would remain in contact with the track, that it would absorb the vapor of water, and that it would prevent in a considerable measure the deposit of soot upon the walls of the tunnel; all advantages which would diminish the formation of rust and so permit of considerable economy upon the cost of maintenance being effected. A trial of the apparatus had been made on March 16, 1899, with good results. The atmosphere of the tunnel was formerly in almost complete equilibrium, or there prevailed a feeble current of air in the direction of south to north. The artificial ventilation had produced, in the direction of north to south, a current with a speed of between 3 m. and 2.8 m. per second; so that the repair of the permanent way between 12th and 13th kilometers from the north entrance could be carried out under excellent conditions, while formerly it was necessary to entirely suspend the work. At this point of the tunnel, a momentary stoppage and re-starting of the fans could be perfectly felt. Enquiry was to be proceeded with as to the exact speed of the fans and the driving power necessary under varying atmospheric conditions, as well as the speed of the current of air at different points in the tunnel.

Mr. G. W. Walker agreed that where fans were employed, and in short tunnels, their best position was about the middle of the tunnels, extracting the foul air from that point and causing the fresh air to rush in at either end. It was perfectly clear that trains did not act as pistons, nor could they efficiently ventilate a tunnel. He did not think the ventilation for tunnels was quite similar to that of mines. The air-resistance in mines was considerable,

owing to the tortuous flues and passages, and a fan working at a high-water gage was necessary. But the resistance in a tunnel due to its large sectional area was practically nil. In dealing with large volumes of air, great caution was necessary, or a considerable waste of power was liable to occur. In a tunnel 1½ miles long and 400 sq. ft. sectional area, the energy spent in moving 240,000 cu. ft. per minute amounted to only 0.8 HP.; but if the volume of air had to be discharged through a duct 4 ft. in diameter and 100 ft. long, the velocity of the air would have to be increased 64 times and the HP. varied as the square of the velocity, which would bring the HP. due to the increase in velocity up to 1,640, friction would absorb an additional 600 HP., and the HP. would thus be raised to 2,224 HP. There was no limit to the waste of power which might result in trying to force large volumes of air through a contracted opening. In the majority of cases of tunnel ventilation, 90% of the power was spent in trying to get the air through contracted outlets or through the fan itself. The latter might have a high efficiency measured by the work done, but 90% of this work might be spent in giving the air an unnecessarily high velocity.

Mr. Edgar Worthington thought that the method of ventilating tunnels on mountain railways by completely closing the mouth after the entrance of a train might be found useful in many cases. It had several advantages over other systems, such as reliability, simplicity and cheapness, especially in Eastern countries where labor was so plentiful. In the summer of 1893, while inspecting the Usui-Toge rack railway in Japan, for the purpose of designing the large four-cylinder locomotive engines, which had since been constructed and were now working this heavy traffic up the long 1 in 15 gradient, he had been requested by the Director of Railways to advise how to ventilate these tunnels, as all known methods had been tried without success. The locomotives on this section of the railway push the trains up the incline at a speed of about 5 miles per hour, and the carriage windows were all closely shut. He had observed, from the locomotive footplate, that the products of combustion gathered in the top of the tunnel, traveling both forwards and backwards, and being very little disturbed by the slowly traveling train. This dense mass of smoke and steam gradually increased in volume, and breathing became impossible, except through some filtering material; and before the end of the tunnel was reached the water-gage lamp, which had previously burned brightly, went out, and the two Japs on the footplate were kneeling with himself with their faces as low as possible to breathe what little oxygen there might be left at the bottom of the tunnel. After this experience he had recommended the Japanese Government to erect a canvas screen at the lower end of each of the worst tunnels, this screen to be closed after the entrance of each train to prevent any air following the train. This was soon done and proved successful. The new locomotives were designed so that the enginemen could also breathe air from the rail-level, in case the screen arrangement proved inefficient.

The author, in conclusion, said that before trains ventured to enter the Appennine Tunnels, the men in charge of trains had to be clothed in thick woolen garments pulled over their clothes. These were wrapped round and round the neck and over the head, and left nothing except a sort of conning-tower slit. In spite of all those precautions the men sometimes arrived at the top of the tunnels in a state of insensibility, but since the Saccardo system had been installed the air was pure and fresh. He supposed most of the members had heard of the accident which occurred in August, 1898, at the Ponte Decimo Tunnel near Genoa. In that case a heavy goods train with three engines was going through the tunnel, when it slipped, and the train came to rest in the tunnel on a steep gradient. All the drivers and firemen were rendered insensible, lying on the footplates, and then the train ran back down to the lower end of the tunnel and crashed into a passenger train which was waiting to ascend the gradient, with the result that 12 persons were killed and 40 injured. That showed that ventilation was, after all, a most important feature in tunnel work.

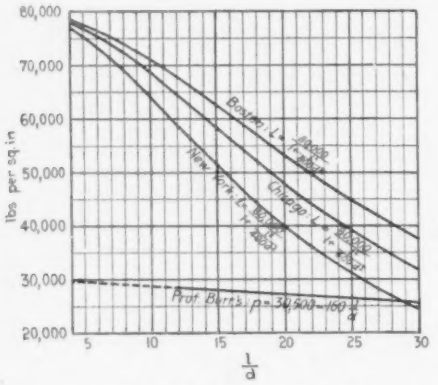


Diagram I.—Ultimate Breaking Loads of Round Columns.

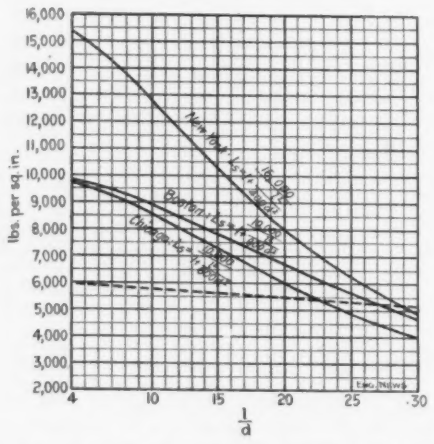


Diagram II.—Safe Loads for Round Columns.

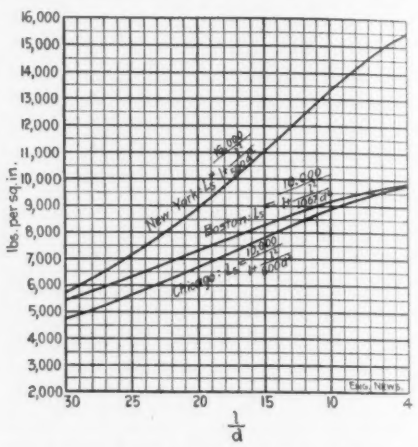


Diagram III.—Safe Loads for Square Columns.

DIAGRAMS SHOWING ULTIMATE AND SAFE LOADS OF CAST-IRON COLUMNS ACCORDING TO DIFFERENT FORMULAS.

CALCULATION OF CAST-IRON COLUMNS.†

By J. B. Nau.*

A rapid and correct calculation of cast-iron columns can be obtained with the use of the accompanying diagrams: Diagram I. represents in graphical construction the ultimate breaking load in pounds per square inch as it will be obtained by calculation with the use of Gordon's formula; and this formula is taken as the basis in the calculation of columns by the Building Laws of New York, Chicago and Boston, as well as other cities.

†Copyright, 1899, by J. B. Nau.
*134 W. 83d St., New York city.

In our illustration we have limited ourselves to the three cities named because the application of the formula in these cases already covers a wide field. In each case the ultimate resistance to compression of cast-iron is taken at 80,000 lbs. per square inch (see Diagram I.), but the coefficient $\frac{l^2}{d^2}$ of $\frac{l^2}{d^2}$ varies with the different cities. It is 400 in New York, 600 in Chicago and 800 in Boston.

The three diagrams have been established with $\frac{l}{d}$ varying between 4 and 30. The city of New York prohibits the use of cast-iron columns of a length of more than 20 diameters, while other cities go as far as 30 diameters. In Diagram I. we furthermore illustrate graphically a formula established by Prof. Burr and based on the actual results obtained with cast-iron columns in a series of breaking tests made by the Building Department of New York city, and another series of similar tests made at the Watertown Arsenal. An inspection of this diagram is very instructive, and shows plainly the wide divergence that exists between the actual breaking loads, as illustrated by Prof. Burr's straight line formula, and the breaking loads that are obtained by calculations from Gordon's formula.

Diagram II. illustrates the safe loads per square inch of cross-section that are allowed by the Building Laws of the three cities named. It must be noticed that the Building Laws of New York

Table of Values of $\frac{l}{d}$.

Length of column:	Diameter or side of column in inches. 6 ins.	7 ins.	8 ins.	9 ins.	10 ins.	11 ins.	12 ins.	13 ins.	14 ins.	15 ins.	16 ins.	18 ins.	20 ins.
6 ft.	12	10.3	9.0	8.0	...	...	...	...	...	...	...	...	...
7 "	14	12.0	10.5	9.3	...	...	...	...	...	...	...	...	...
8 "	16	13.7	12.0	10.7	9.6	8.7	8.0	7.4	6.9	6.4	6.0	5.3	4.8
9 "	18	15.4	13.5	12.0	10.8	9.8	9.0	8.3	7.7	7.2	6.7	6.0	5.4
10 "	20	17.1	15.0	13.3	12.0	10.9	10.0	9.2	8.6	8.0	7.5	6.7	6.0
11 "	22	18.8	16.5	14.6	13.2	12.0	11.0	10.1	9.4	8.8	8.2	7.3	6.6
12 "	24	20.6	18.0	16.0	14.4	13.1	12.0	11.1	10.3	9.6	9.0	8.0	7.2
13 "	26	22.3	19.5	17.3	15.6	14.2	13.0	12.0	11.1	10.4	9.7	8.7	7.8
14 "	28	24.0	21.0	18.6	16.8	15.3	14.0	12.9	12.0	11.2	10.5	9.3	8.4
15 "	30	25.7	22.5	20.0	18.0	16.4	15.0	13.8	12.9	12.0	11.3	10.0	9.0
16 "	..	27.4	24.0	21.3	19.2	17.4	16.0	14.8	13.7	12.8	12.0	10.7	9.6
17 "	..	29.1	25.5	22.6	20.4	18.5	17.0	15.7	14.6	13.6	12.7	11.3	10.2
18 "	..	30.9	27.0	24.0	21.6	19.6	18.0	16.6	15.4	14.4	13.5	12.0	10.8
19 "	..	....	28.5	25.3	22.8	20.7	19.0	17.5	16.3	15.2	14.2	12.7	11.4
20 "	..	....	30.0	26.6	24.0	21.8	20.0	18.5	17.1	16.0	15.0	13.3	12.0
21 "	..	....	....	28.0	25.2	22.9	21.0	19.4	18.0	16.8	15.7	14.0	12.6
22 "	..	....	....	29.3	26.4	24.0	22.0	20.3	18.8	17.6	16.5	14.7	13.2
23 "	..	....	....	30.6	27.6	25.1	23.0	21.2	19.7	18.4	17.2	15.3	13.8
24 "	..	....	....	....	28.8	26.2	24.0	22.2	20.6	19.2	18.0	16.0	14.4
25 "	..	....	....	....	30.0	27.3	25.0	23.1	21.4	20.0	18.7	16.7	15.0
26 "	..	....	....	....	....	28.4	26.0	24.0	22.3	20.8	19.5	17.3	15.6
27 "	..	....	....	....	....	29.4	27.0	24.9	23.1	21.6	20.2	18.0	16.2
28 "	..	....	....	....	....	30.5	28.0	25.8	24.0	22.4	21.0	18.7	16.8
29 "	..	....	....	....	....	....	29.0	26.8	24.8	23.2	21.7	19.3	17.4
30 "	..	....	....	....	....	....	30.0	27.7	25.7	24.0	22.5	20.0	18.0

Table of Areas "A," and Radii of Gyration "R."

Size of column.	A.	R.	Size of column.	A.	R.
6 × ¾ ins.	12.4	1.87	13 × 1⅝ ins.	58.0	4.06
6 × ⅞ "	14.1	1.84	13 × 1¾ "	61.9	4.02
6 × 1 "	15.7	1.80	13 × 2 "	69.1	3.95
7 × ¾ "	14.7	2.23	14 × 1 "	40.8	4.61
7 × ⅞ "	16.8	2.19	14 × 1¼ "	50.1	4.53
7 × 1 "	18.9	2.14	14 × 1½ "	58.9	4.45
7 × 1½ "	20.8	2.11	14 × 1⅝ "	63.2	4.41
8 × ¾ "	17.1	2.57	14 × 1¾ "	67.4	4.37
8 × ⅞ "	19.6	2.53	14 × 2 "	75.4	4.30
8 × 1 "	22.0	2.50	14 × 2¼ "	79.2	4.26
8 × 1⅛ "	24.3	2.46	15 × 1 "	44.0	4.96
9 × ¾ "	19.4	2.93	15 × 1¼ "	54.0	4.88
9 × ⅞ "	22.3	2.89	15 × 1½ "	63.6	4.80
9 × 1 "	25.1	2.85	15 × 1⅝ "	68.3	4.76
9 × 1¼ "	27.8	2.81	15 × 1¾ "	72.9	4.73
9 × 1½ "	30.4	2.77	15 × 2 "	81.7	4.65
9 × 1⅝ "	35.3	2.70	15 × 2¼ "	85.9	4.61
10 × ⅞ "	25.1	3.24	15 × 2½ "	90.1	4.57
10 × 1 "	28.3	3.20	16 × 1¼ "	57.8	5.23
10 × 1¼ "	31.4	3.16	16 × 1½ "	68.3	5.15
10 × 1⅛ "	34.4	3.12	16 × 1⅝ "	73.3	5.11
10 × 1½ "	40.1	3.05	16 × 1¾ "	78.3	5.07
10 × 1⅝ "	42.7	3.01	16 × 1⅞ "	83.2	5.04
10 × 1¾ "	45.4	2.98	16 × 2 "	87.9	5.00
11 × 1 "	31.4	3.55	16 × 2⅛ "	92.6	4.96
11 × 1⅛ "	34.9	3.51	16 × 2¼ "	97.2	4.91
11 × 1¼ "	38.3	3.47	18 × 1½ "	77.8	5.85
11 × 1½ "	44.8	3.39	18 × 1⅝ "	83.6	5.82
11 × 1⅝ "	47.9	3.36	18 × 1¾ "	89.3	5.78
11 × 1¾ "	50.9	3.32	18 × 1⅞ "	95.0	5.74
12 × ⅞ "	30.6	3.94	18 × 2 "	100.5	5.70
12 × 1 "	34.6	3.90	18 × 2¼ "	106.0	5.66
12 × 1¼ "	38.4	3.87	18 × 2½ "	111.3	5.62
12 × 1½ "	42.2	3.83	18 × 2⅝ "	116.6	5.59
12 × 1⅝ "	45.9	3.79	18 × 2¾ "	121.7	5.55
12 × 1¾ "	49.5	3.75	20 × 1½ "	87.2	6.56
12 × 1⅞ "	53.0	3.71	20 × 1⅝ "	93.1	6.52
12 × 1⅝ "	56.4	3.67	20 × 1¾ "	100.3	6.48
12 × 1⅞ "	59.6	3.64	20 × 1⅞ "	106.7	6.44
12 × 2 "	62.8	3.60	20 × 2 "	113.1	6.40
13 × 1 "	37.7	4.26	20 × 2¼ "	125.4	6.32
13 × 1⅛ "	41.9	4.22	20 × 2⅝ "	131.5	6.28
13 × 1¼ "	46.1	4.17	20 × 2¼ "	137.4	6.24
13 × 1⅜ "	54.2	4.10			

city allow 16,000 lbs. as a safe load per square inch of cast-iron, which corresponds to a factor of safety of 5; while both Chicago and Boston allow only 10,000 lbs., corresponding to a factor of safety of 8. In this diagram we have again represented in dotted lines the straight line formula of Prof. Burr; and, for the sake of comparison, we have applied to the formula a factor of safety of 5. On account of the greater factor of safety taken by Chicago and Boston, cast-iron columns in those cities come much nearer actual conditions than in the case of New York. It results from Diagram II. that the Building Laws of New York allow a column of 4 diameters to carry 15,400 lbs. per square inch, while actual testing has shown that such a column would safely carry only about 6,000 lbs. per square inch, with a factor of safety of 5.

Diagram III. represents the safe loads that square cast-iron columns are allowed to carry under the application of Gordon's formula in the three cities named with the same factors of safety as for round columns. To facilitate the calculation of the strength of columns by means of these graphical curves we have added a table giving the value of $\frac{l}{d}$ for columns varying from 6 ins. to 20 ins. diameter, and in length from 6 ft. to 30 ft. In still another table we have added the areas of columns from 6 ins. to 20 ins. diameter for different thicknesses of metal. This last table also contains the radius of gyration of each column. This radius is not required in the use of the curves, but as it is often convenient to have them we have introduced them in the table.

As an illustration of the method of using the diagrams we herewith submit an example: How much can a round cast-iron column of 10 ins. diameter and 14 ft. height, with 1¼ ins. thickness of metal, safely carry according to any of the above Building Laws? $\frac{l}{d}$ expressed in the same unit is found to be 16.8. Diagram II. for $\frac{l}{d} =$ 16.8 will show that such a column will safely carry 9,400 lbs. per square inch, according to New York Law; 7,400 lbs. according to Boston Law, and 6,800 lbs. according to Chicago Law. In the table of areas the cross-section of the column is given at 34.4 sq. ins. The column can therefore safely carry a total load of

34.4 × 9,400 = 323,360 lbs. = 161.6 tons in New York.
34.4 × 7,400 = 254,560 " = 127.3 " Boston.
34.4 × 6,800 = 233,920 " = 116.9 " Chicago.

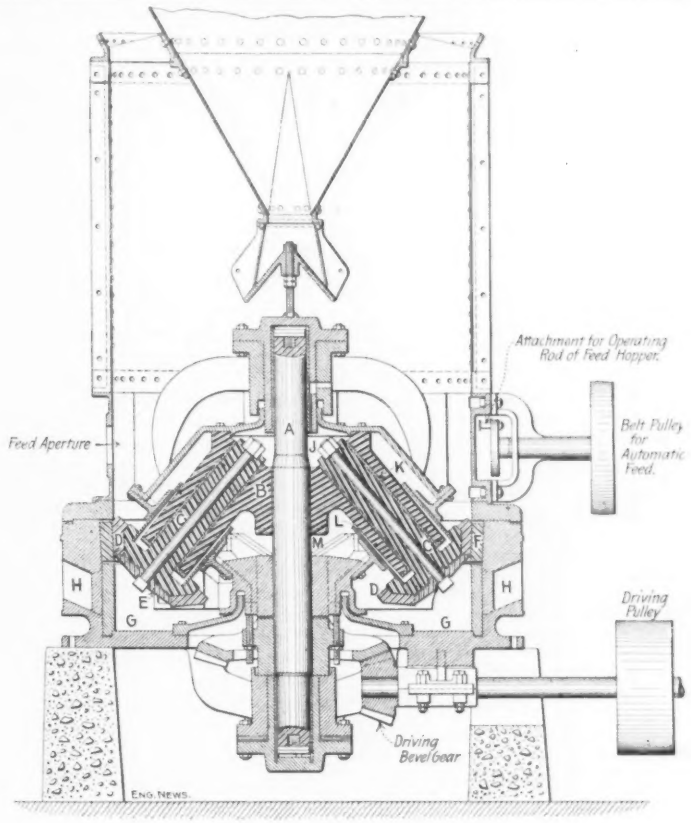
The diagram can also be used to find what column is required to carry a given load.

A NEW ROLLER GRINDING MILL.

The great number of manufacturing processes which involve the grinding of raw material or of the product, has led to a great development in grinding mills, and the Raymond mill, which we illustrate this week, presents some novel and interesting features in its construction. Upon the vertical shaft (A) is keyed a cast-steel spider (B), in which are journaled three or four mushroom-headed rolls (C). The head of each roll is fitted with a crushing ring (D), secured by the cap plate (E), and a bolt passing lengthwise through the roll. The crushing rings (D) are normally in contact with the fixed crushing ring (F), and the crushed product finds its way down between these contact surfaces. Should a piece of hard rock or some foreign substance, such as an iron spike or bolt, find its way into the mill, it would simply force the roll back, the roll moving diagonally upward in its sleeve-bearing in the spider. As soon as the obstacle has passed, the roll will return to position by gravity and by centrifugal force.

The product falls through into the chamber (G), meeting a current of air which enters at (H), and passes upward through the mill. The air current carries up the "fines" to the separator, and the fineness of the "fines" can be regulated by varying the force of the air current. The coarser material, or "tailings," in the chamber (G) is raised by plows between the arms of the spider and delivered above the crushing rolls again. The plows come down within 2 ins. of the bottom of the chamber, leaving a space in which any foreign matter will lie undisturbed until the mill is cleaned out. At (J) is an oil chamber, and the oil which passes down the sleeve bearings (K) of the rolls must return through the annular passage (L) into the chamber (M).

A special feature claimed for the mill is that it does fine grinding at low speed. The shaft and spider make about 100 revolutions per minute, while the crushing rolls make about 250 revolutions in their sleeve bearings during the same period. In capacity of output, in uniformity and fineness of product, and in power required to operate it, this mill is claimed to be superior to other mills used for the same purposes. It is in use for grinding gypsum, talc and marble dust, and has been tried successfully on cement. The mill is the invention of Mr. Albert Raymond, and is manufactured by the Raymond Bros. Impact Pulverizer Co., 1402 Monadnock Block, Chicago, Ill.



ROLLER GRINDING MILL.
Raymond Bros. Impact Pulverizer Co., Manufacturers.

THE SEAVEY ISLAND PRISON FOR CAPTIVE SPANIARDS.

The last issue of the "Proceedings" of the U. S. Naval Institute contains a short article by Lieut. R. H. Jackson, U. S. N., which well illustrates characteristic American "hustle" in meeting an emergency.

As a result of the naval battle of Santiago, on July 3, 1898, 1,700 Spanish prisoners were left upon the American warships and auxiliary vessels. A military prison and camp had to be provided for these men, and the Navy Department selected Seavey's Island, near Portsmouth, N. H., as the site of the camp, and at once let contracts for building a stockade, barracks, kitchen, closets, etc. Information was received that the first 700 prisoners would arrive at the camp on July 11, and Paymaster Loomis was ordered to proceed to Portsmouth and report to the commandant of the camp for duty as commissary.

He arrived at Portsmouth on Saturday, July 9, and at once inspected the camp. He found the kitchen only outlined by a few frames and some flooring; there was no shelter for stores, and the stoves were still in Boston. Paymaster Loomis at once communicated with the Department at Washington, on the long-distance telephone, and received full authority to act as both quartermaster and commissary, as it was the wish of the Department that every preparation be made for the health and comfort of the prisoners on their arrival. The contractor was then interviewed, and though he said it was "impossible," the kitchen was under cover by Saturday night. The stove-dealer was also ordered to have his ranges up and "fire in them" by Sunday night; and by that time 21 ranges were brought from Boston, set up and fired. In a similar manner ten cooks were found in Portsmouth and were at their stations.

By noon on Monday, July 11, 700 prisoners were mustered ashore on Seavey's Island; and then sat down to a hot dinner of coffee, fresh beef, fresh bread, potatoes and onions. Immediately on landing each man received a hammock, mattress and two blankets, and they were swung and used that night. All needful clothing and shoes were furnished them; medical officers were detailed to look after the health of the prisoners, and two Spanish priests, who were among the captives, attended to their spiritual wants.

This camp was broken up on Sept. 12, when the prisoners sailed for Spain, healthier, stronger and better-fed than in all their lives before. The resources displayed on the part of American officers in utilizing the material on hand, the promptness of execution and the perfection of all details, makes the establishment of this camp worthy of special notice, and is in striking contrast to the methods of the nation whose prisoners were so well cared for. It might be further mentioned that though the food supplied was good and abundant, the cost averaged for two months only 19 cts. per day per capita.

A NEW TEXTILE PLANT is being experimented with in Russia, says U. S. Consul Atwell, of Rouhaix. This is the "Apocynum venetum," a bush about 6 ft. high yielding a silken fiber. It grows in Europe, Siberia, Asia Minor, North of India, Manchuria and Japan, and it has long been used by the Turcomans in the manufacture of cords and woven goods. It has never been cultivated, and grows best in land under water for part of the year. The fiber has great strength and its cultivation would require no care. In 1895, the Russian government began to use it for bank-note paper, and the results were so excellent that the plant has since been cultivated at Poltava.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, } ASSOCIATE EDITORS.

A. B. GILBERT, - - - - - - - ASSISTANT MANAGER.

CHAS. W. REINHARDT, - - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York, M. C. ROBBINS, Chicago, S. B. READ, Boston, C. F. WALKER, Cleveland, } ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.
CLEVELAND OFFICE, OSBORN BUILDING.
LONDON OFFICE, EFFINGHAM HOUSE, 1 ARUNDEL ST., STRAND.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current year, 15 cents.

In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 329 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1899; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXII. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

Electric railway accidents have been remarkably frequent of late, and one thing which has been forcibly brought to the attention of railway managers in connection with them is the need of better braking apparatus. In the Bridgeport disaster of Aug. 6, with its 30 fatalities, investigation showed that the car ran for some distance after derailment before it plunged over the side of the bridge. In Brooklyn last week, while a crowded car of the Fifth Ave. line was descending a steep grade at high speed, a wheel broke, the brakes were rendered inoperative, and the car ran a considerable distance and finally stopped with its front end overhanging the side of a bridge 50 ft. in height. On the same day a runaway occurred on a steep grade of an electric railway at Norristown, Pa. According to reports, both the ordinary brake and an "emergency brake" were unable to stop the car, which ran down a grade a quarter of a mile long, left the track at a curve at its foot, and plunged against the houses at the side of the street. It is also stated that a week previous, 30 persons were injured in a similar accident on the same road.

We fully appreciate that for use in crowded city streets, where speeds are slow and the brake is being applied every few seconds, the hand brake has advantages which are exceedingly difficult to duplicate in any power brake. The need of a power brake for emergency use, however, especially on railways which run cars on suburban lines at high speed, and which operate over steep grades, is becoming more and more apparent. It is to be hoped that the series of brake tests which is being conducted this week under direction of the New York State Railroad Commission, and of which we expect to give a report next week, may furnish some data of practical value in this field.

We give considerable space in this issue to a recent paper and discussion before the Institution of Civil Engineers upon the ventilation of tunnels, a subject on which very little information of any practical value is to be found in engineering literature. It appears from this discussion that in Europe, as in this country, the great majority of railway tunnels get along with only such ventilation as the winds and other natural currents of air provide. It is only on the longest tunnels, and those in which traffic is heavy, that the nuisance of smoke and steam has become so great as to compel the adoption of some sort of ventilating system.

Two things have combined to prevent the proper ventilation of tunnels, the absence of means for cheaply distributing power, and ignorance of those in charge as to the proper design of a plant for economical ventilation. Even at the present day the design of ventilating systems too frequently betrays a lack of comprehension by the designer of the conditions which govern the economical movement of air. One of the most pertinent points brought out in the entire discussion of the paper referred to above was that made by Mr. Walker, to the effect that an astonishingly small amount of power is required to ventilate a tunnel, provided it is properly applied. The whole secret is to keep the velocities and pressures very low at all points of the passage, including the passage through the fan itself. Remember that the horse power required to move air varies as the square of its velocity at the point where its velocity is highest. Of course this means a large size construction at the mouth of the tunnel where the ventilating apparatus is installed; but such a construction will pay in reducing the consumption of power.

Even more important than reducing the consumption of power, in many cases, is reducing the labor of attendance. So long as the steam engine was the only motor available, tunnel ventilating systems were naturally few, but now that several automatic motors are to be had, tunnel ventilating plants ought to be much more common. Either an electric motor, a gasoline engine or a water-wheel attached to a fan, can safely be left to run itself day in and day out, with only an occasional visit from an attendant. Of these three the water-wheel commends itself especially for its simplicity and economy. We believe there are a great many cases of tunnels located in mountainous districts, where a small stream of water could be brought in pipes to the tunnel mouth and delivered under such pressure as to run an impulse wheel attached to a fan of sufficient size to keep the tunnel clear of smoke, and the whole plant could be run the year round at no expense, save the cost of oil and occasional renewal of bearings.

It will be understood, of course, that we are now referring to tunnels remote from towns and cities. For ventilating subways and tunnels in cities, electric motors are doubtless to be preferred to any other system, since the current can usually be purchased, and at a very low rate, in consideration of its being used for 24 hours in the day.

We are glad to be able to report another convert to the principles that every municipal department should stand on its own bottom, and that the cost of municipal services should be divided between private and public consumers, according to benefits received. The city council of Grand Rapids, Mich., has acceded to the request of the Board of Public Works in this matter to the extent of transferring money from the park to the water fund for water used in the parks and of making a much larger transfer from the contingent to the water fund. The situation is well described by the Grand Rapids "Democrat," in words that apply so well to numerous other places that we quote it for the benefit of water-works superintendents and city officials generally, who have been struggling for the recognition and practical application of the principles expressed:

> The free water plan has been adhered to because of the belief that it was only a matter of bookkeeping, that the public had to foot the bills anyway, and it made little or no difference through what fund they were paid. But the study of the water problem by Mayor Perry and the members of the present board has made it manifest that under the existing system a very considerable part of the cost of water for fire protection, the parks and other public uses did not fall on the general public, where it belongs, but upon the water consumers. The income from the water consumers, with this public use load, did not justify any reduction of rates, even where the rates are admitted to be too high, while if the board can have credit for its work, that is, pay for all the water consumed, it will open the way to an equalization of rates and a decrease to the average consumer.
>
> The action of the council last evening in providing for the payment of the water used by the parks is the first step toward placing the water business of the city in a position so that it can be self-sustaining.
>
> By the more general introduction of meters, too, it is expected the board will be able to diminish the amount of water pumped. The amount of water consumed per day per inhabitant in this city for three years past has been over 150 gallons. The amount consumed in other cities of this class averages but half this amount, running from 27 to 82 gallons per inhabitant per day.

The meter proposition, mentioned in the last paragraph, is also in the line of both progress and equity. It is as essential to justice that the burden of water supply be properly distributed between the private consumers as between them and the general public.

Our attention has been drawn to the correspondence in our issue of July 29, concerning the value of reducing curvature in railway location, and it has been suggested that some fuller explanation of the rule for estimating this value might be of interest at the present time. As Mr. McHenry states, the rule adopted on the Northern Pacific was taken from Wellington's "Economic Theory of Railway Location." One entire chapter of that work, covering 84 pages, was devoted to the subject of curvature; and the meat of the whole may be summed up in the estimate that each degree of curvature increases the operating expenses per train mile by .0593 ct., or it increases the annual operating expenses per daily train run by 365 times this, or 43.3 cts. This sum will pay interest at 6% on $7.20. Hence, in round numbers, $7 is taken as the value per degree of reducing curvature in the instructions to locating engineers on the Northern Pacific.

It has occurred to us that it may be worth while at this time to review this estimate, and see what changes in it may be advisable to correspond with the changes in conditions which have occurred in the dozen years and over since the estimate was made. We give herewith from the original work the table referred to in full:

TABLE 115.—Estimated Average Cost per Train-Mile of 600° of Curvature.

(Being equivalent to a continuous 11° 20′ curve, 1 mile long, assumed to double the average train resistance in lbs. per ton.)

(Cost of train-mile assumed at $1.00.)

Items, as per Table 80.	Average cost of item, cts. or per cent.	Per cent. added by 600° of curvature, as above.	Cost due to curvature.
Fuel	7.6	50	3.8
Water	0.4	25	0.1
Oil and waste	0.8	25	0.2
Repairs, engines	5.6	125	7.0
Switching-engine service	5.2	Unaffected	0.0
Train wages and supplies.	15.4	Unaffected	0.0
Repairs, cars.	10.0	120	12.0
Car mileage	2.0	Unaffected	0.0
Rail renewals	2.0	300	6.0
Adjusting track	6.0	50	3.0
Renewing ties	3.0	50	1.5
Earthwork, ballast, etc..	4.0	50	2.0
Yards and structures	8.0	Unaffected	0.0
Station and general	30.0	Unaffected	0.0
Total cost,* cts. pr cent	100.0	35.6	35.6

Total cost per train-mile.....35.6% ÷ 600° = 0.0593 ct.
Total cost of 1° of curvature per year per daily train (0.0593 ct. × 365 × 2) = 43.3 cts.

*Per train-mile of 600° of curvature.

It will be seen that of the 35.6 cts. which is estimated to be added to the cost of operation of a train over a mile of road with 600° of curvature, 25 cts. are due to three items, viz.: car repairs, engine repairs and rail renewals. Even when these estimates were made, the author expressed the opinion that they were probably too large; and they were set at so high a figure merely to make sure that they should be large enough. Under present conditions these items, it seems to us, are so much overestimated that a reduction ought to be made in the interest of accuracy. The effect of curvature on car and engine repairs, as was pointed out by Mr. Wellington, is almost wholly confined to the wear of wheels and tires. Both of these cost much less now than when the above table was compiled, and the use of tire-dressing brakeshoes has made the expense of repairing

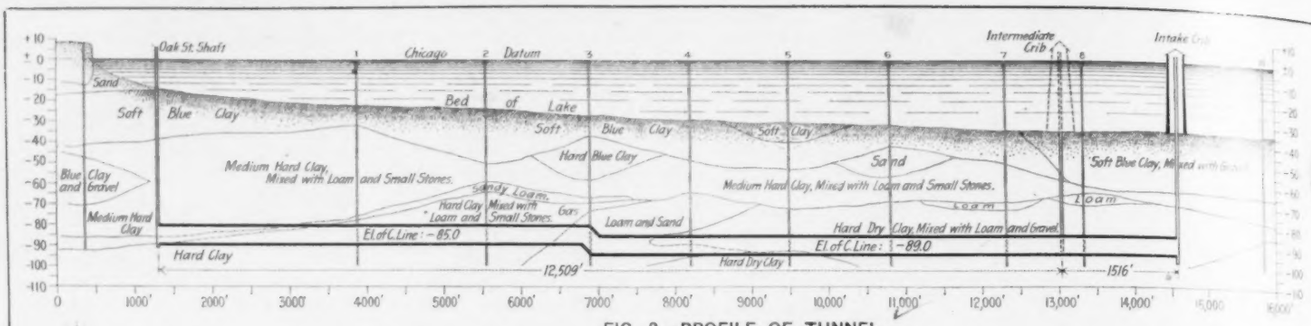
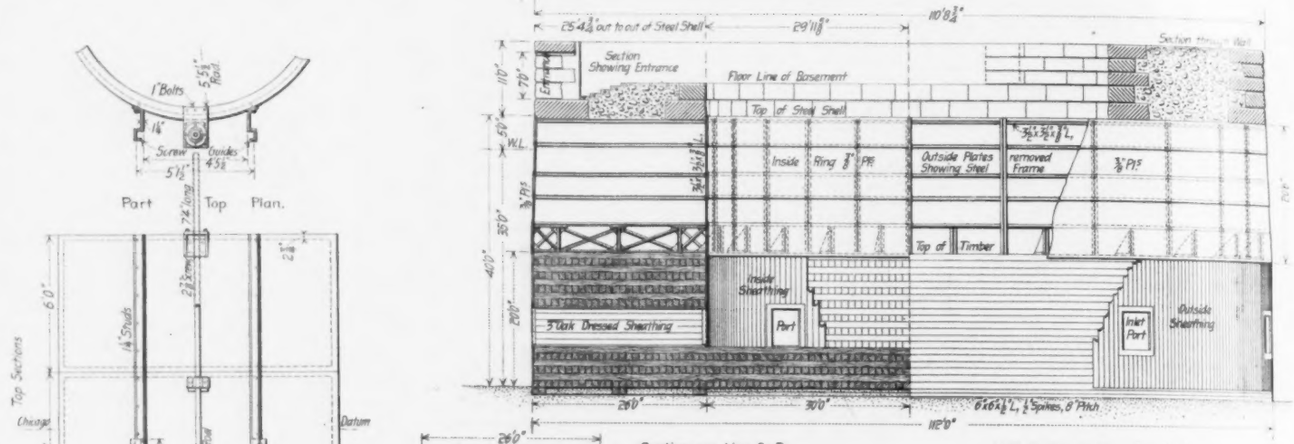
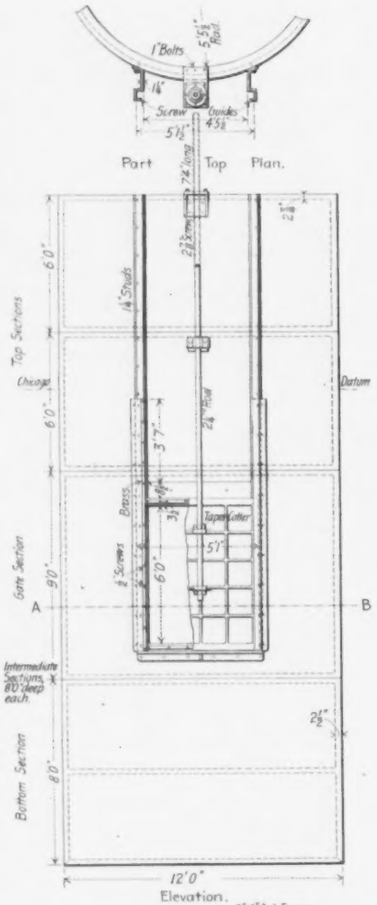


FIG. 3.—PROFILE OF TUNNEL.





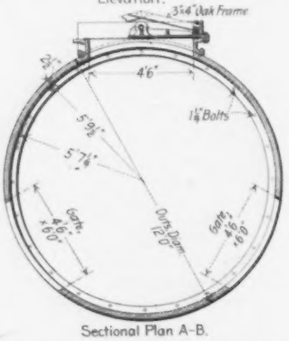
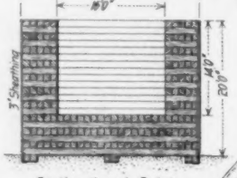


FIG. 4.—INTAKE SHAFT WITH GATES.



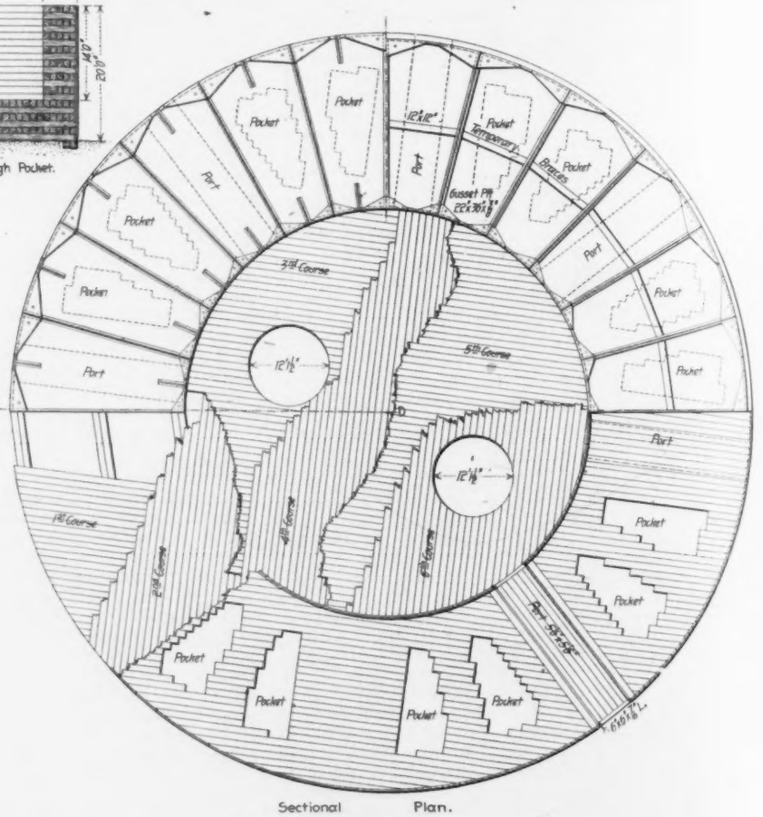


FIG. 5.—NEW INTAKE CRIB.

TUNNELS, INTAKE CRIB AND PUMPING STATIONS

L. E. McGann, Commissioner of Public Works.

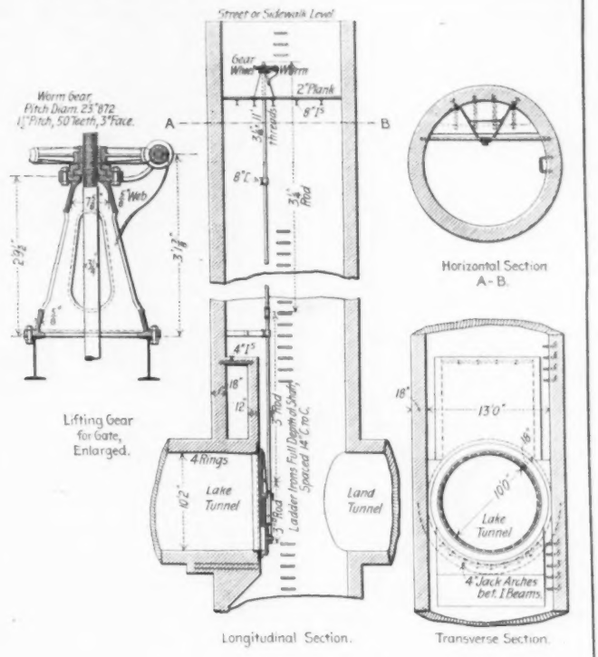


FIG. 2.—SHORE SHAFT OF TUNNEL.

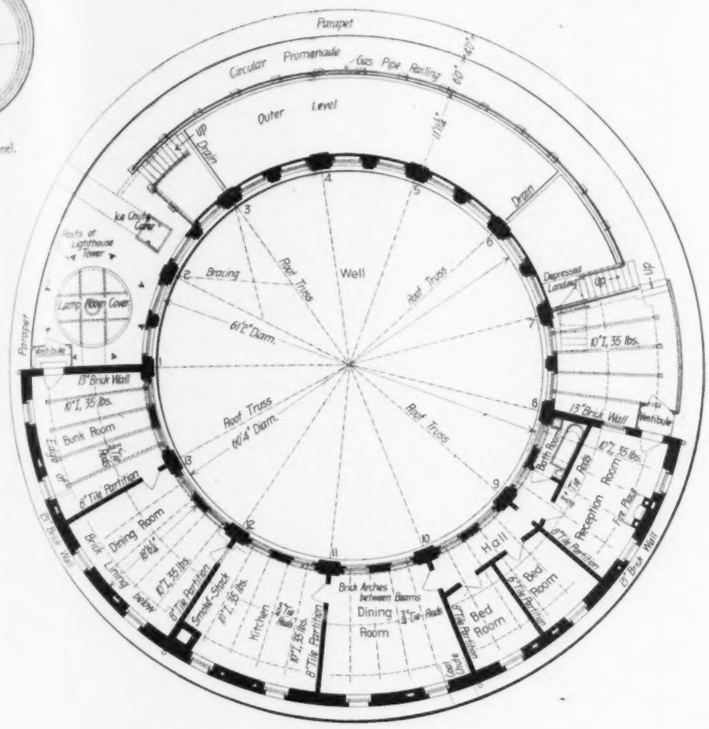


FIG. 9.—MAIN FLOOR PLAN OF CRIB.

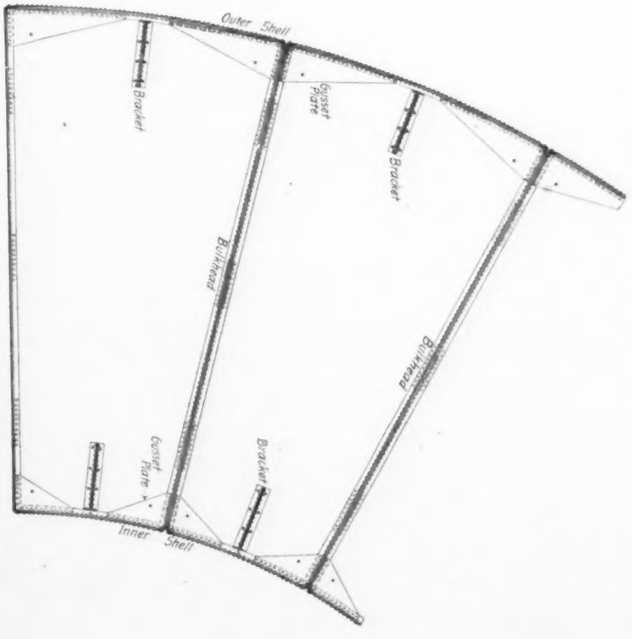


FIG. 7.
PART HORIZONTAL SECTION OF STEEL PORTION OF INTAKE CRIB.

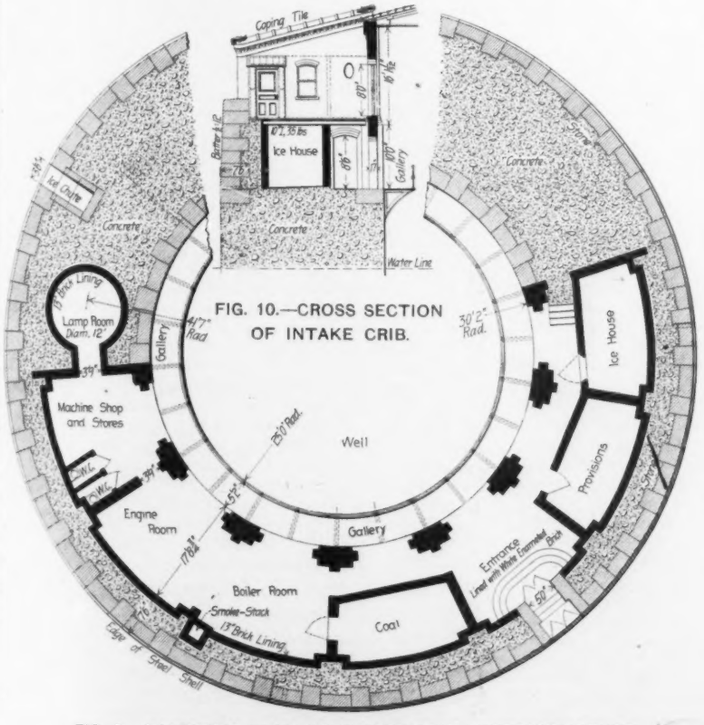


FIG. 10.—CROSS SECTION OF INTAKE CRIB.

FIG. 8.—BASEMENT PLAN OF INTAKE CRIB SUPERSTRUCTURE.

STATIONS FOR ADDITIONAL WATER SUPPLY; CHICAGO, ILL.

John Ericson, City Engineer.

worn tires on locomotives much less than formerly. It seems altogether probable, therefore, that the estimate of the increase of engine and car repairs due to curvature might be reduced by 50%, and be nearer the truth. To look at it from another point of view; does it seem reasonable to suppose that a railway line with continuous 11° 20′ curves for its whole length would have its entire operating expenses increased by more than one-third over those of a road of the same length built on a tangent throughout? It seems to us that this is an extravagant estimate.

It is of interest to quote here the paragraph which follows the above table in the work:

> The similar estimate which the writer made in the first edition of this treatise gave a smaller estimate for the value of curvature than this, viz., 22.5 cts., instead of 35.6 cts. for the cost per train-mile of 600° of curvature—a difference of over 50%, and this in spite of the fact that the former estimate was for the most part on an iron-rail basis. The only positive reason for this difference is that the writer has seen reason to increase the estimate of the effect of curvature on rolling stock repairs, although a chief reason has been to insure that the estimate was large enough. According to the above estimate, the total cost of a train-mile should be 10% greater on a road having 100° more curvature, which is the most that the evidence warrants.

At the present time we believe it is entirely proper to return to Mr. Wellington's original figures and set the operating expenses per train-mile due to 600° of curvature at 22.5 cts. It also appears proper to use 320 as the number of days in the year that a "daily train" is run, as so few trains are run on Sunday. We would then have the cost per train-mile per degree at 22.5 cts. ÷ 600 = 0.0375 ct., and the cost per annum per daily train at .0375 ct. × 320 × 2 = 24 cts. With interest at 6%, this would be the interest on $4, which may be taken as the limit of the amount which it will be profitable to spend, per daily train expected to be run, to save a degree of curvature in the original construction of a railway.

We may add the caution that this estimate was intended by Mr. Wellington to apply only within the limits in which the locating engineer has usually the opportunity to exercise his discretion. As he said on p. 274 of his work: "If it were a question between 2° curves or 20°, or between no curvature and a great deal, it might well make a serious difference; but under ordinary circumstances the question is rather between, say, 6° and 10° curves, or between 10% more and 10% less curvature."

The fact that the price of pig iron has doubled in a little over six months shows the extent of the present activity in industrial lines. All prices of manufactured iron and steel have advanced in about the same ratio; and it is now almost impossible to buy structural steel in any quantity, as many of the mills are sold up for a year or more in advance. That a reaction will follow the present boom may be taken as certain. In fact, the price of iron and steel products has already reached such a point that construction work requiring the use of large quantities of iron or steel is being postponed, wherever possible, and it is certainly wise financiering to do this. Unless the trust combinations should prove strong enough to dictate prices, regardless of the relations of supply and demand, it may be taken as certain that in the long run iron and steel will be made and sold at prices as low as is consistent with a fair profit to the manufacturer. It needs only a comparison of present prices with those of 1897 to show that iron manufacturers are now making such great profits as cannot in the nature of things be permanent.

THE BREAKAGE OF STEEL RAILS.

Among the recently published papers read before the Institution of Civil Engineers which have come to our notice, is one which bears the attractive title "The Effects of Wear Upon Steel Rails." Its author is Mr. W. G. Kirkaldy, son of the noted David Kirkaldy, and successor in charge of the famous testing laboratory which his father established. There is also included a paper by Sir Wm. Roberts-Austen on "The Photo-Micrography of Steel Rails," and these two papers, with the long discussion upon them, make up a bulky pamphlet of 112 pages. We were never more reminded, however, of Gratiano's "two grains of wheat in two bushels of chaff." A large part of the discussion is from the same old "rounders," whose practical knowledge of the subject under discussion is most limited, and who apparently talk only that the time shall not run to waste.

We shall try, for the benefit of our readers, to extract the facts of practical interest which are contained in this mass, and to present them with some comments of our own.

In the first place, it appears that in November, 1895, a rail on the Great Northern Ry., in England, broke into several pieces. Mr. Kirkaldy was asked to investigate the cause of the fracture. This he did by testing speciments cut from various parts of the rail, and he reached the conclusion that the metal in the head of the rail had deteriorated, as a tensile test specimen cut from it showed only 58,100-lbs. tensile strength, and 1½% reduction of area, while the metal in the base of the rail showed 94,145 lbs. strength and 31½% reduction of area. He then continues as follows:

> Judging from the behavior of the specimens from the heads of these two short pieces of rail, the deterioration arose primarily from what may be termed "hammer-hardening" of the running surface, caused by the passing of the wheels of trains; and following upon this hardening the development of minute cracks—transversely to the length of the rail—which had gradually extended or penetrated downwards into the rail-head from the hardened top surface.
>
> The deterioration having been found from the tensile tests to lie entirely in the top of the rail, the impression formed from an examination of the original fractures was confirmed. It was thus conclusively shown that the original fracture had taken place through the top of the rail failing, while that portion was placed in tension through the reverse flexure of the rail under the traveling load; and, moreover, that fracture lies immediately over the place where the rail was supported by a chair and sleeper, as shown by chair mark or gall on the underside.

After monkeying some more with these pieces of rail, Mr. Kirkaldy succeeded in finding a number of flaws, which he concluded to be due to the wear and "hammer-hardening" to which the rail had been subjected. In one case he found "a multitude of cross-flaws in the head of the rail. In fact, the head was practically disintegrated."

We may note here that the chemical analysis of several samples from this rail showed: Carbon, 0.234 to 0.540; Silicon, 0.038 to 0.130; Sulphur, 0.065 to 0.106; Phosphorus, 0.065 to 0.125; Manganese, 0.300 to 0.493.

Mr. Kirkaldy was then furnished with six old rails taken up near the spot where the broken rail had been in service, and these he tested by bending them under a steady load with the heads down. These rails had been in service from 20 to 22 years, and under this treatment they all broke at a deflection of ¼ to 1.3 ins., in a 5-ft. span, whereas when subjected to the same test right side up they stood 6 to 9 ins. deflection without fracture. Four more rails from different parts of the line were then tested with more encouraging results. One of them is worth noting, as it was situated on the main line, and had been in service for 23 years, yet it had only lost 2.38 lbs. per yd. in that time (its original weight being 80 lbs.). The author then continued his studies, testing rails from the Great Eastern, the Great Northern, the Metropolitan, and other roads, and as a result of all his work he propounds—in rather a tentative way, it is true—the theory that after the rolling and consequent hardening of the head of the rail has gone on for some time a "disintegration" is set up consisting in the formation of induced cracks and flaws, which will develop until the rail breaks, unless they are detected and the rail removed. He thinks this "deterioration" may be partly due to the influence of the wheels upon the rails when a train is being retarded by the brakes, or is being started by an engine with slipping drivers. He favors the use of harder rails of deeper section as a means of securing longer life; and in this practical recommendation he is in accord with the best practice of American engineers. He also suggests that annealing might restore the rail to its original condition, and tests showed that this was the case. The practical value of this suggestion, however, is obviously very small. To take up its rails, anneal and relay them would be a task that no railway company is likely to undertake. So much for the paper. Turning now to the discussion, most of the practical railway men who took part in it did not appear seriously alarmed over Mr. Kirkaldy's presentment.

The venerable Sir Lowthian Bell remarked that he had been a steel manufacturer for 25 years and a director of the Northeastern Ry. for the same length of time. The number of rails which were broken in the track averaged, as nearly as he was able to compute, 1 in 3,500, by which we suppose he meant 1 in every 3,500 rails laid. Mr. Footner, of the London & Northwestern R. R., said that he had kept a record of rail breakages on that system for 12 years. The total number was 388; but he did not remember a single case where an accident had been caused by a broken rail. Taking the average life of a rail on the London & Northwestern Ry. at 20 years, he found that the average rate of breakage of the rails was 1 in 2,000. We quote further from the report of his remarks as follows:

> In trying to ascertain the primary cause of the breakages he had noted and classified the rails according to their position and conditions of service in the track. As regards the seasons they broke as follows: 29 per cent. in the spring, 16 per cent. in summer, 22 per cent. in autumn and 33 per cent. in winter. As regards their position in curves and tangents, 27 per cent. broke in curves from 5 to 60 chains radius, 24 per cent. in curves of radii exceeding 60 chains and 49 per cent. in straight lines. Of those broken in curves nearly two-thirds were in the lower rail. As regards the position of the fractures—
>
> 11 per cent. subjected to brake action. } broke between the fish-plates within 10 ins.
> 27 per cent. not subjected to brake action. } of the end of the rail.
>
> 36 per cent. subjected to brake action. } broke elsewhere at various parts of the rail.
> 26 per cent. not subjected to brake action. }
>
> Of the fractures between the fish-plates 85 per cent. were at the end at which the wheels came on them, and 15 per cent. at the end at which the wheels left them. Of the fractures not between the fish-plates 30 per cent. occurred at a chair, and 70 per cent. between the chairs. As regards the weights at which 84-lb. bull-headed rails broke—
>
> | | | | | | | |
> |---|---|---|---|---|---|---|
> | 10 | per cent. | broke | between | 84 lbs. | and | 80 lbs. |
> | 31 | " | " | " | 80 " | " | 75 " |
> | 28 | " | " | " | 75 " | " | 70 " |
> | 16 | " | " | " | 70 " | " | 65 " |
> | 11 | " | " | " | 65 " | " | 60 " |
> | 4 | " | " | below | 60 " | | |
>
> As regards the weights of traffic carried by the rails before breaking—
>
> 3 per cent. broke after carrying between ¼ million and 2½ million tons.
> 35 per cent. broke after carrying between 2½ million and 25 million tons.
> 45 per cent. broke after carrying between 25 million and 50 million tons.
> 17 per cent. broke after carrying between 50 million and 100 million tons.
>
> The life of the broken rails in the line was—
>
3	per cent.	between	0	years and	5	years.
23	"	"	5	" "	10	"
36	"	"	10	" "	15	"
24	"	"	15	" "	20	"
4	"	over	20	"		
10	"	age unknown.				
>
> From the foregoing particulars it was seen that neither the age nor the weight of the rail, nor the amount of traffic, nor the influence of the seasons, nor the position in curves and tangents, nor the action of brakes or trains starting, took any such leading part as to justify the assumption that any one of them determined the fractures.

Mr. F. E. Robertson said that when he was Chief Engineer of the East Indian Ry., the percentage of broken rails was 1 in 495,000 per annum, and the average age of broken rails was 11 years.

Mr. Thos. Andrews, consulting metallurgical expert to the Great Northern and other British railway companies, exhibited by lantern slides magnified sections of rails. These indicated that the minute transverse cracks across the railhead alluded to by Mr. Kirkaldy were probably due to sulphur in the metal. Mr. Andrews opposed the use of rails with carbon in excess of 0.42% and manganese in excess of 0.85%. Apropos of the wear of rails, he showed one sample from the Manchester, Sheffield & Lincolnshire Ry., which had been in the track 24 years, and whose wear had been 0.3-lb. per yd. per annum. It contained 0.25% of carbon and 0.43% of manganese. Mr. T. R. Johnson, Mr. Andrews' assistant, gave an account of an 80-lb. rail in the track of the Great Northern Ry. for 18 years, and which had carried a traffic estimated at 120,000,000 tons. It was on a 2.2% grade. The amount of wear was 5 lbs. per yd. in the 18 years, and the top was worn off 3-16-in.

In general, the tenor of the discussion was to the effect that Mr. Kirkaldy's theory that flaws were likely to be set up in any rail by long-continued use, was wholly contrary to the results of experience, and that with a proper chemical composition and methods of manufacture, a worn rail was—save for its reduced section—no more likely to break than a new one.

In this respect, we believe that English experience coincides with the American. The increase in weight of rolling stock in this country has been kept pace with by the increase in the weight of

rail sections, and so far as our knowledge extends, rail breakages are if anything less frequent now than they were 20 years ago.

It is worth pointing out that the English style of track is more conducive by far to rail breakages than the American. English rails are supported on 12 or 13 cast-iron chairs to a 32-ft. rail length. American track uses about 16 ties to a 30-ft. rail, and the effect is much the same as if the rail were supported on a continuous elastic cushion of timber. The fact that American track stands up so well under the heavy traffic and large wheel-loads which are common here is doubtless largely due to the close spacing of the ties.

LETTERS TO THE EDITOR.

Stream Pollution Fallacies.

Sir: I mail you herewith a copy of the Memphis "Commercial Appeal," of Aug. 7, which makes two remarkable statements in its editorial "The Chicago Canal," viz.: "Water ordinarily purifies itself in seven miles," and "ordinary sewage is not dangerous." There is nothing in the context to modify either of these statements, and the readers of that article can quote and believe these statements to the detriment of public health. The editor of the "Commercial Appeal" is a very bright man, usually well-informed and "level-headed." The journal exerts a great influence in shaping public opinion in Tennessee, Mississippi and Arkansas, where water supplies and sanitary methods of disposing of sewage are not as well developed as they will be in the future. The time when such developments will be made will be greatly delayed if such statements from such an influential journal go unchallenged. There is need of missionary work on that editor. A good beginning in the missionary work would be for you to send him a list of books on these two subjects, which laymen can easily understand, and to urge him to read Engineering News for six months. K.

Yazoo City, Miss., Aug. 12, 1899.

(It takes a long time for an error once spread broadcast to be wholly rooted out. That old fallacy concerning the speedy self-purification of streams was once pretty firmly fastened upon the engineering profession itself, and it is only in very recent times that it has been wholly abandoned. It is not strange, therefore, that a non-professional man should be found still believing in it. —Ed.)

Concerning Roof-Truss Design.

Sir: In your issue of Aug. 17 I notice an attempt by Mr. W. W. Brush, C. E., to calculate the details of a truss designed by me; and as his calculations apparently show my design to be poor and I incapable of appreciating even the most elementary stresses, I beg you in defense both of my net design and my own reputation to find place for the following explanation:

The drawing of the truss was nothing but a sketch, and surely it is not fair to apply a scale on such a drawing. I drew it on purpose to no scale and for no particular loading, as I merely wanted to illustrate a new principle of construction. The truss for which this sketch was originally made carries, as trusses very often do, a ceiling on the lower chord, and for this reason the chord members were designed for bending and tension. The oak blocks were made 8 ins. long and cut ¾-in. into the chord, but they were afterwards changed to 2½-in. cast-iron blocks. The chord strain was 18,000 lbs. and the reaction 16,000 lbs.

Tension in bolts: $18{,}000 \div 1.5 = 12{,}000$ lbs. per sq. in.

Bearing of blocks in chord: $18{,}000 \div 2 \times \frac{3}{4} \times 8 = 1{,}500$ lbs. per sq. in.

Shear in blocks: $18{,}000 \div 8 \times 8 \times 2 = 140$ lbs. per sq. in.

Bearing in post: $16{,}000 \div 1\frac{1}{2} \times 8 = 1{,}330$ lbs. per sq. in.

I believe all these strains to be well inside of safe limits for yellow pine and oak respectively. The bearing on yellow pine I think could safely be increased to 2,000 lbs. per sq. in., provided splitting is prevented by a few small bolts through the 2-in. pieces of chord immediately back of the blocks. So that by cutting in blocks 1 in. and making them of cast-iron a tension stress of $8 \times 2 \times 2{,}000 = 32{,}000$ lbs. could be provided for. The main advantage, however, of this construction over the one suggested by Mr. Brush and all previous designs is the ease with which the different members can be brought to a firm bearing. Where reliance is placed on bolts in bearing the shrinkage of the green timber, that generally has to be used where large structures are in question, leaves the bolts loose, allowing heavy vibrations under wind pressure. In fact, I believe such loose joints are responsible for the collapse of most wooden sheds. In the design suggested by me a few turns of the nuts after the timber has dried out is all that is necessary to make every member do its duty. Respectfully yours,

Gunwald Aus, M. Am. Soc. C. E.

Treasury Dept., Washington, D.C., Aug. 22, 1899.

Locking-Bar Steel Pipe Lines.

Sir: If I am not taking up your valuable time too much, I should like to make a few remarks on your very interesting article in Engineering News of June 29, 1899, that arrived by last mail, entitled "Some Notable Australian Steel Pipe Lines."

A few years ago, in 1897, I believe, Messrs. Mephan Ferguson & Co., Melbourne, made some very exhaustive tests with various kinds of riveted, seamless and the lock-bar type of steel pipes. The latter proved capable of standing a higher pressure than the other descriptions tested, and certainly will stand a far higher test than a main is ever asked to do, even with the most trying fluctuating pressures caused by the opening and shutting of big valves under very high pressure. The lock-bar joint, as appears in your paper, should give every satisfaction, providing a perfectly water-tight and yet not an absolutely rigid joint, allowing for very considerable expansion and contraction, as would be experienced if used on the Coolgardie scheme. It should prove most satisfactory and thus save upsetting the alinement of the pipe, that often happens to rigid joints, under such heat as is experienced in dry countries such as West and South Australia.

I should like to point out that you are evidently under a wrong impression with regard to the locality of the Bundaleer water supply, and Adelaide. The Coolgardie scheme is in West Australia, and the Engineer-in-Chief of that Colony is Mr. C. Y. O'Connor, M. Inst. C. E., and not Mr. Moncrieff. I know this from personal experience, having done a considerable amount of engineering work there and having personally got out the contract drawings for the Coolgardie water scheme, including valves, pipes, valve tower, dam and other collateral work. Adelaide is the capital of South Australia, and the Bundaleer water supply is purely a South Australian work, and one of the best bits carried out in that colony. Mr. C. Y. O'Connor went over to Adelaide to inspect it during the construction and to see how the lock-bar pipe and fittings behaved.

I am, dear sir, Yours faithfully,

Edward C. Buck, C. E.
Assistant Engineer, Grand Junction Railway.

Port Elizabeth, Cape Colony, July 29, 1899.

(We regret the slip of the pen, in our issue of June 29, by which we placed Adelaide, the Bundaleer water-works, and our highly esteemed correspondent of many years' standing, Mr. Alex. B. Moncrieff, M. Inst. C. E., M. Am. Soc. C. E., in West instead of South Australia.—Ed.)

A 198-Ft. Dive in Tacoma Harbor.

Sir: A successful descent was made by William Baldwin on August 9, into 33 fathoms of water, in Tacoma Harbor, Washington. The object sought was to view the position of the ship "Andelana," which turned turtle in that harbor on the night of Jan. 13, through the loss of one of the ballast logs which were hung by chains to the ship's sides to hold her steady, as the ballast had been all moved on the previous day, as reported in Engineering News of Jan. 26.

The diver reached the vessel and reports her as lying easily on her port side with very little damage done, and only a small amount of silt having accumulated upon her, although she lies at the mouth of the Puyallup, which is a heavy silt bearing glacial stream. The diver reports all conditions favorable for raising the vessel by means of pneumatic tubes or compressed air. Work is to be undertaken at once, and it is hoped will be carried to completion within 30 days.

A special armor was used for this trip, details of which will be furnished at some later date. So far as is known this is the deepest submarine work of authentic record.

A. McL. Hawks.

Tacoma, Washington, Aug. 11, 1899.

(A press dispatch of Aug. 17, received since this letter was in type, states that this William Baldwin lost his life on that day, in another attempt to reach the "Andelana." He had descended about 150 ft. when he signalled distress; he was hauled to the top, but life was extinct when he reached the surface. Another letter just received from Mr. Hawks says that the accident was due to the partial failure of the air-pump, though a slight leak in the middle piston had been repaired by Baldwin himself and the pump tested by him before his descent. All attempts to supply him with air from the other two cylinders were unavailing.

Mr. Walter S. Wheeler, of Seattle, in this connection, asks whether it is possible for a man, with the diving apparatus now in use, to live at a depth of 190 ft. below the water surface; and adds that another diver lost his life in Puget Sound, several years ago, in an attempt to descend to a depth of 195 ft. In the case of the diver Baldwin, it is evident that he did successfully make one descent to a depth of about 190 ft.; and the report says that he lost his life in the second attempt, when at a depth of only 150 ft., by the failure of the packing in his air-pump. He had, therefore, successfully withstood the pressure of nearly six atmospheres, or almost 90 lbs. per sq. in. in excess of atmospheric pressure. The deepest descent of which we can find any record, is that reported by the Messrs. Seibe, noted makers of diving apparatus, in London. This firm tells of one Hooper, who some years ago made seven descents to a depth of 201 ft., in removing the cargo of the ship "Cape Horn," wrecked on the South American coast. Hooper is credited with having remained below, at one time, 42 minutes. We also have reports of sponge-divers descending to depths of 160 and 200 ft. without injury.

While these statements are more or less reliable, in 1895, Mr. Hersent, engineer of the harbor works at Bordeaux, France, made a careful series of experiments intended to demonstrate the extent of human endurance in compressed air work. He had a test-chamber built, and fitted with windows, telephone, electric light and steam coils, and three men volunteered for the tests. One of these was a regular compressed-air worker; the second was an occasional worker, and the third had only been in the working chamber a few times. These men were subjected to pressures for about one hour at a time, increasing about 4.27 lbs. per day. One man finally withstood a pressure of 76.8 lbs. per sq. in., raised to that point in 45 minutes; it was continued for one hour, and then reduced to normal pressure in 3 h. 3 m. He felt no inconvenience from this experience, other than a slight tingling, which soon passed away. This pressure is equivalent to a depth of about 177 ft. below the water surface; and the tests of Mr. Hersent tend to prove that in air-lock work, a healthy man can safely undergo this pressure, provided that sufficient time is taken to restore normal conditions. In this case, while the maximum pressure was exerted in 45 minutes, the reduction of the pressure required about four times 45 minutes. In the case of a diver, the conditions are not favorable for the extreme care shown in Mr. Hersent's experiments; and any sudden change of pressure, such as would be caused by any failure in the pumps, would be fatal, as in the case of Mr. Baldwin. The extreme limit of compressed air work seems to have been reached at the East River Gas Co.'s tunnel under the East River, described in our issue of July 11, 1895. Here, the greatest pressure was 52 lbs., equivalent to a depth of 120 ft. A full account of Mr. Hersent's experiments will be found in our issue of Aug. 1, 1895.—Ed.)

Why Not Print Prices?

Sir: This is a plaint from an engineer in a small interior town. Can you print it? Why do manufacturers get out such costly circulars and publications and flood the country with them and not give prices?

The writer had some plans to prepare and estimates to give on work for a small place. It was noted in the papers and letters commenced to pour in from all over the United States. The writers were modest. They invariably asked for full copies of the plans and specifications so they could give figures on the work. Some asked to be given an opportunity to bid. Some unblushingly offered to give a little private commission if satisfactory arrangements could be made. And such gorgeous circulars and catalogues as some sent. Masterpieces of the printers' art. All sizes and shapes. Some on the finest and heaviest smooth paper. Some on costly paper so rough that it was difficult to read the descriptive letterpress. Everyone of them claimed to have the best pumps and other machinery in the world. Some gave the distinctive points in their machines; others gave general descriptions. But not one of them contained prices. Of what use are they?

Let us reason together. In the first place, it is impossible to send copies of the plans and specifications to all who ask, for there are too many, and the country engineer barely gets enough pay for a job to be lucky if he can pay to have two or three copies struck off on the typewriter. He has to hustle to get his job at all. These same big houses nearly all offer to prepare plans free of charge and the average councilman in a country town thinks the money spent on an engineer is to be charged entirely to the expense account.

In the second place, they generally wait until the last minute before employing an engineer and then are in a terrible hurry to get his figures. The engineer must first write off to dealers who advertise and get their catalogues and he always asks for priced catalogues. He gets in re-

turn magnificent art productions and a request for his plans and specifications so special figures can be given. He simply has not the time to do it, and oftentimes he has to give estimates on very short notice.

Now I know what the manufacturer will say; but he is foolish. Why cannot he give prices in his catalogue for all the machinery he advertises, date his catalogue and send discount sheets? Why does he print "Prices on application," instead of giving some prices—even approximate? But as a rule the machinery on which prices are wanted, and wanted badly—engines, boilers and pumps—is never quoted, and the man has to give exactly what he wants or he gets no prices. The greater number of the elegant pamphlets go to the waste-paper basket, although the writer preserves his in a carefully indexed pamphlet library. But he wants more figures and not so many pure art souvenirs.

If the prices were there, the manufacturer could be sure of making some engineers happy, and perhaps, have his machinery mentioned in a report. It is a foolish waste of money to print such useless things. The same extravagant claims of duty and power are made in all the catalogues. They read as if all written in the same back-shop, and as they are all apparently equal in quality, the man who receives them is forced to believe the only difference is in price and he cannot get a price without writing for it.

Then the engineer cannot give his plans and specifications until after the council takes some action. The writer has had some experience in this line of work in quite a number of cases. A law of the state generally prescribes how much of a bond issue can be provided for any particular work. The engineer prepares his plans for water-works or sewerage to keep within the limits of the bonds to be issued. Then he sends a report with his plans to the council. That body "chews" on it for a week or two, then sends it back to have the estimates revised once or twice until a plan is finally evolved which is satisfactory. Next comes the preparation of the bond election. This has generally to be advertised six or eight weeks in advance. If the bonds carry, the engineer then prepares his full specifications, and the work is advertised for.

The wise manufacturer when he concludes to correspond with an engineer whom he learns is to prepare plans should send him priced catalogues of ALL the machinery and appliances he thinks will be needed in the work, and send discount sheets. The engineer will appreciate it and preserve the information. In his grateful state of mind he is likely to send notice of the letting of bids if it is not advertised in some engineering paper. But it is often impossible to send plans and specifications for a long time and sometimes impossible to send them at all. It is no light job to prepare copies and until the town pays for printing them he cannot do it. And another thing: I have received on this last small job over 100 letters in three or four weeks, and I have answered them all, for I never let a letter go unanswered. And some firms have been very insistent. They have written from one to four letters, all of which had to be answered. Yet only one firm sent a stamped addressed letter for reply.

I know they have gone to a great expense for advertising and that the sending of a stamped addressed envelope means the spending of more money, but they must consider, when they demand replies, that the average engineer has hard work making a living, especially in a small place, and that there are hundreds of firms writing to him, and that to answer them all takes a lot of his time. It does him no good—they are the ones benefited, or to be benefited. He cannot afford to answer all the letters he receives and pay the postage. If they expect to get business they can do it by sending such full information, including prices of their goods that he cannot fail to look them up, and if they write letters expecting replies, they should send stamped addressed envelopes. I have heard manufacturers complain because they got so few replies to the letters sent out and such small returns from catalogues. They fail on the letters because the engineer cannot well afford the time and stamps to answer the letters, and they fail to get good from their catalogues because the things are of awkward size and give no prices. Give us catalogues of uniform size, printed sensibly as if printed by ordinary business men and not millionaires, and give us prices, PRICES, **PRICES**—even if they change every week. Sometimes men come into an office and want an estimate while they wait. Please help us to give something approximate, for if he has to wait for us to secure them he will not call again, but will deal with the house direct. Perhaps the house wants this?. Quien sabe? Engineer.

Idaho, Aug. 16, 1899.

Elements of Design Favorable to the Speed Regulation of Plants Driven by Water.

Sir: In the condensed report of Mr. Allan V. Garratt's paper on the above subject, appearing in your issue of July 27, there is a statement made to the effect that the whole of the energy which is given out by the body of water within a penstock, when its velocity is reduced, is expended upon the water-wheel. This occurs on page 51, where, after calculating the kinetic energy which will appear, when a mass of 1,000,000 lbs. of water, within the penstock, is reduced in velocity from 4 ft. to 2 ft. per second, Mr. Garratt says that this amount of energy, "186,330 ft.-lbs., must be expended upon the water-wheel before the velocity is reduced to 2 ft. per second."

This assumption, which is a very general one, seems to me to be incorrect. The amount of energy stated is undoubtedly developed, but the point I wish to show is that it is not all "expended upon the wheel."

Take the penstock dealt with in Mr. Garratt's paper, which was 300 ft. long, 9-ft. head, and containing 1,000,000 lbs. of water, which water is reduced in velocity, by partly closing the gate, from 4 ft. to 2 ft. per second. Such a penstock will be about 54 sq. ft. in cross-section, if of uniform sectional area. If the reduction in velocity from 4 ft. to 2 ft. per second is made in two seconds, the mean pressure at the end of the penstock during these two seconds, or "mean time pressure," may be found by dividing the amount of energy developed, 186,330 ft.-lbs., by the distance in feet, which the body of water travels while it is being arrested. Assuming the retardation to be uniform, this distance will equal the mean velocity multiplied by the number of seconds, 3 ft. × 2 secs. = 6 ft., and the mean time pressure will therefore = 186,330 ÷ 6 = 31,055 lbs., or 575 lbs. per sq. ft., or as Mr. Garratt gives it by a different formula, 3.97 lbs. per sq. in.

The 186,330 ft.-lbs. of energy will thus be absorbed when the column of water has been flowing for a distance of 6 ft. in an interval of 2 seconds, against a back-pressure of 575 lbs. per square foot (the reaction equaling the action).

But the additional pressure of 575 lbs. per sq. ft. only acts upon the water-wheel when such pressure is referred directly to it—that it to say, on the minimum areas represented by the orifices of the guides, as it is only on these orifices that the increased pressure accelerates the water acting on the wheel. The pressure on other areas than these does not tend to accelerate the velocity of the water, nor to force more water through the guides.

In practice the area of the guides will be less than that of the penstock, and therefore only such proportion of the 186,330 ft.-lbs. will be taken up by the wheel, as is represented by the proportional areas of penstock and guides. Assuming the aggregate minimum area of the guides to be 9 sq. ft., and the penstock being 54 sq. ft. area, it will be seen that only one-sixth of the pressure produced by retarding the water column is taken up by the wheel, the remaining five-sixths being resisted by the end of the penstock and other dead faces.

If the whole of the energy was to be taken up by the wheel, the whole pressure due to retardation would have to be referred to the orifices of the guides, producing a pressure there of 3,450 lbs. per sq. ft., the adjacent surfaces carrying the 562 lbs. per sq. ft. due to the head.

But this is clearly impossible.

The case is rendered more clear if a straight vertical penstock is considered, in which the bottom is formed by a casting with properly shaped guides, the runner being beneath with its axis coinciding with the vertical axis of the penstock. The change of pressure at the orifice of the guides, due to inertia of the water column, will only be affected by the column immediately above the orifice, and not by the whole column within the penstock. "Reductio ad absurdum," let the penstock be 50 ft. diameter, and the wheel 1 ft. diameter, and let the water run through the penstock at 4 ft. per second by a gate at the bottom. If this gate were suddenly closed, leaving the wheel still in communication, and supposing the penstock strong enough to withstand the strain, it is very evident that the 90,000,000 ft.-lbs. of energy which would be developed would not be "expended upon the wheel."

Turning again to Mr. Garratt's figures, he tells us, in the case we have been considering, that "169 HP. would be expended upon the wheel for two seconds, while the water column was being retarded." Lower down in the same column (page 51) he shows how the effect of inertia would produce a result similar to increasing the head from 9 ft. to 18.2 ft. in a stand-pipe of sufficient height, placed near the turbine at the lower end of the penstock. The maximum effect this could produce would be to double the power of the wheel for the time being, if the gate were wide open all the time, but as the gate could not be wide open under the circumstances, the power of the wheel would be less than doubled.

The actual effect would be that the wheel would develop its full power during the time that the head was being virtually doubled, though the gate would only be half open.

As the penstock was 54 ft. area, and the water flowed at 4 ft. per second, with 9 ft. head, the maximum power of the wheel, neglecting all losses, = 54 × 4 × 60 × 9 ÷ 550 = 212 HP. Even supposing that the output would be doubled by doubling the head, and reducing the gate opening, we have an increased output of 212 × 2 ÷ 60 = 7.1 HP. for two seconds. There is thus a considerable difference between 7.1 HP. and 169 HP., the error arising through the assumption that the whole of the energy of the moving column is expended on the wheel.

Of course the question will have presented itself, what becomes of this energy? A case can be easily imagined when the gate could be immediately completely shut, and the penstock made sufficiently strong to withstand the strain. What becomes of the energy then? It is doubtless partly converted into heat, and partly absorbed by overcoming molecular cohesion.

Yours truly, John Sturgess,
Chief Engineer Reynolds Turbine Governor Co.
95 State St., Albany, N. Y.

(We give space to Mr. Sturgess' letter, since others may have had the same difficulty in studying this matter that he has evidently experienced, and it may be of service to them to point out wherein the error lies, for Mr. Garratt's statement was undoubtedly correct. The error in the above letter is the assumption that the energy of the moving mass of water can be absorbed by the reaction of the fixed end of the penstock. The fact is that energy can only be absorbed by doing work against resistance. In other words, unless the end of the penstock yields somewhat to the pressure, it can absorb none of the energy of the moving mass of water. The thing to be borne in mind is that the time it will take to reduce the velocity of the water from 4 ft. to 2 ft. per second, in the example cited by Mr. Sturgess, depends directly upon the time in which the surplus energy can be absorbed, and cannot be assumed at two seconds or any other period of time unless we also assume that some means are provided for absorbing the energy in that time. In the case of Mr. Sturgess' "reductio ad absurdum," he assumes that the penstock is made strong enough to stand the strain, but he had better first compute what pressure would be exerted when the gate is suddenly closed. He will find that, except for the elasticity of the walls of the penstock and of the water itself, the pressure developed will reach the ultimate strength of the penstock walls, no matter how great that might be made.

This matter is so important to every one concerned with controlling the flow of water in pipes, whether for water power or water supply purposes, that it ought to be clearly understood. It can be made simpler by removing the waterwheel from consideration. Suppose we have a gate-valve at the end of a long pipe, in which the water is flowing at a rate of 4 ft. per second. Suppose by suitable mechanism we instantly close the gate to one-half the full opening of the pipe. The water will then flow through this reduced opening at double its former velocity, or 8 ft. per second, and the pressure set up in the pipe will be exactly that required to cause this velocity. Of course both velocity and pressure instantly begin to decrease, and this decrease continues until an equilibrium is reached between the head and the resistance. Thus the surplus energy due to the fall in velocity of the moving mass is all absorbed in discharging the water through the contracted gate opening at a higher velocity than that due to the normal head.

It may also be pointed out in this connection that the surplus energy due to a reduction in velocity need not necessarily be expended on the wheel. The provision of escape valves, for example, will dispose of a part of the energy; an advantage is gained, too, by placing the gates which control the flow beyond the wheel, in the draft tube. In this case the accelerated flow through the opening when the gate is partially closed does not act upon the wheel.—Ed.)

Notes and Queries.

Apropos of the letter relating to the operations of C. E. Coon & Co., of Toledo, O., referred to in our issue of Aug. 10, p. 89, Mr. Theo. W. Hill, of Charleston, W. Va., writes us that he was at one time associated with this concern, and can give direct information to anyone desiring to know more concerning them.

NEW TUNNELS, INTAKE CRIB AND PUMPING STATIONS, CHICAGO, ILL.

(With two-page plate.)

One of the most extensive and important additions to the water supply system of Chicago will be provided by the new 10-ft. lake tunnel with its intake crib 2.70 miles from shore, and by the completion of the two land tunnels connecting with the lake tunnel, each of which will supply a new pumping station of large capacity. The general situation is explained by Fig. 1, which shows the position of the tunnels, crib and pumping stations.

The work is all under the jurisdiction of Mr.

L. E. McGann, Commissioner of Public Works. The general planning of the scheme, with the preparation of the plans and the execution of the work, have all been under the direction of Mr. John Ericson, City Engineer of Chicago.

Lake Tunnel.

The new lake tunnel, which is termed the Northeast Lake Tunnel, extends northeast from the shore shaft at Oak St. to an intake shaft 2.70 miles distant. The tunnel is of circular section, 10 ft. in diameter, and is lined with four rings of brick. Work was commenced in July, 1896, and was completed from the Oak St. shaft to the intermediate shaft, 12,504 ft., in September, 1898. Since then the intake shaft has been completed and the tunnel between the two lake or crib shafts. The contract for the tunnel, intake shaft and protection crib was awarded in 1896 to the FitzSimons & Connell Co., of Chicago, which also had the contract for the first section of the land tunnel. Mr. C. T. Anderson was the engineer in charge of the lake tunnel until September, 1896, when he was succeeded by Mr. E. W. Jackson, with Mr. H. H. Jackman, M. Am. Soc. C. E., as assistant. Mr. Jackson resigned in April, 1898, and was succeeded by Mr. Jackman, who remained in charge until the completion of the work.

The Oak St. shaft was commenced July 17, 1896, and completed on Aug. 14. Owing to the quantity of water encountered, it was necessary to use a steel caisson 14 ft. 6 ins. diameter and 24 ft. deep for the upper part of the shaft, the caisson being lined with two rings of brick, leaving a clear inside diameter of 13 ft. Below this the shaft was lined with four rings of brick, the lining being built in sections from 4 to 6 ft. deep, supported by steel plates on the ends of vertical suspension rods. The depth of the shaft is 100 ft., the center line of the tunnel being 100.15 ft. below the street grade. The construction of the Oak St. or shore shaft is shown in Fig. 2.

Fig. 3 is a profile of the tunnel, showing the character of the material encountered. The material was partly hard clay and partly a soft blue swelling clay, which caused considerable trouble and delay. This latter material was encountered mainly in the roof. The size of the excavation made it necessary to have the roof timbered, but the masonry lining was kept close up to the working face.

During the latter part of March, 1897, electrical power was installed, a 10-HP. locomotive of special design being used, which could haul in the tunnel eight cars of 1 cu. yd. capacity, at a rate of six miles an hour. During that year the character of the material encountered was a hard blue clay, interspersed with pebbles and bowlders in the bottom and center; overlying this was a rotten clay of varying thickness, and above all a stratum of soft swelling clay. Pockets of black sand, some dry and others carrying water and gas, were encountered. On Oct. 20, when the face of the drift was 5,278 ft. from the shaft, a large deposit of black sand and water was encountered. There was a consequent material reduction in the rate of progress until Oct. 28, when apparently solid ground was again encountered. On the morning of Oct. 30, a few moments after a blast had been set off in the heading (about 15 ft. from the toothing or end of the masonry lining) a break occurred in the roof near the face, through which first came a quantity of dry lake sand, immediately followed by black sand, water and gas. The heading filled up to the toothing with silt and sand, running back about 75 ft. A temporary brick bulkhead was at once constructed at Station 52, provided with a door and ventilating and drainage pipes. On Nov. 28 the contractors resumed work, believing the material in the face had drained out sufficiently to allow of its being handled. By carefully timbering every foot of progress a 7-ft. length was completed; but while the silt was being removed from the section immediately under the hole in the roof, the soft blue clay followed, completely filling up the heading, and showing so much activity that it was deemed impossible to hold it up with the facilities at hand. The face was securely timbered and the contractors suspended work, pending a consideration of the proper means to be employed in order to drift through this place.

In March, 1898, the contractors commenced the installation of a compressed air plant, and an air lock 40 ft. long was constructed in the tunnel, 5,050 ft. from the Oak St. shaft. This lock was 6 ft. inside diameter and 33 ft. long inside, having a capacity for six dump cars. By May 6, this lock was completed and in such shape as to withstand a pressure equal to that of the inflowing water, sand and gas. For 17 days work was then prosecuted under air pressure for a distance of 73 ft. During June, drifting was prosecuted for 14 days under air pressure, making a total advance of 81 ft. The contractors were again obliged to use air pressure for a period of seven days, from July 7 to 14, during which time a length of 74 ft. was driven. During the intervals between the times in which air pressure was used, excavation was carried on under ordinary conditions. The highest pressure maintained at any time was 30 lbs., the average being 22 lbs. at the lock, which was located 329 ft. from the working face, and at the end of one mile of 3-in. air pipe. The remainder of the drift was completed without encountering any abnormal conditions, the clay being quite hard, interspersed with small bowlders and gravel.

The work was carried on in three shifts. The heading gang, working from 11 p. m. to 7 a. m., excavated the semicircular top heading for a length of 15 to 20 ft., and set temporary roof timbering, consisting of vertical posts in the center of the heading, about 8 ft. apart, with top caps 3 ft. long. When necessary, radial struts extended from the feet of the posts to the sides of the excavation. The posts and struts rested on jacks. Where the roof caved in the openings were timbered and afterwards filled in with masonry. The trimming gang, working from 7 a. m. to 3 p. m., excavated the lower portion of the tunnel section and put in the timbering. This consisted of crutches or inverted V-frames of inclined posts, extending from the haunches of the invert to the crown. Radial struts and blocks extended from the posts to the upper part of the excavation, and a 3 × 10-in. plank formed a longitudinal cap, fitting between the tops of the crutch frames. The feet of the crutches, the heads of the struts, and the sides of the cap, were all fitted up with wedges. In hard clay the excavation was blasted out. The trimming gang also laid a working floor and track, and put in the invert centers. The mason gang, working from 3 to 11 p. m., first laid the invert, and then the sides, working on each side alternately, until the arch was nearly completed, one man then laying the key section.

The tunnel was originally intended to have four rings of brick, laid in natural cement mortar, but while part is built in this way, the remaining portion has three rings laid in Portland cement, which construction is found to be equally as strong as the other. The finished section is about 10 ft. 2 ins. high and 10 ft. wide.

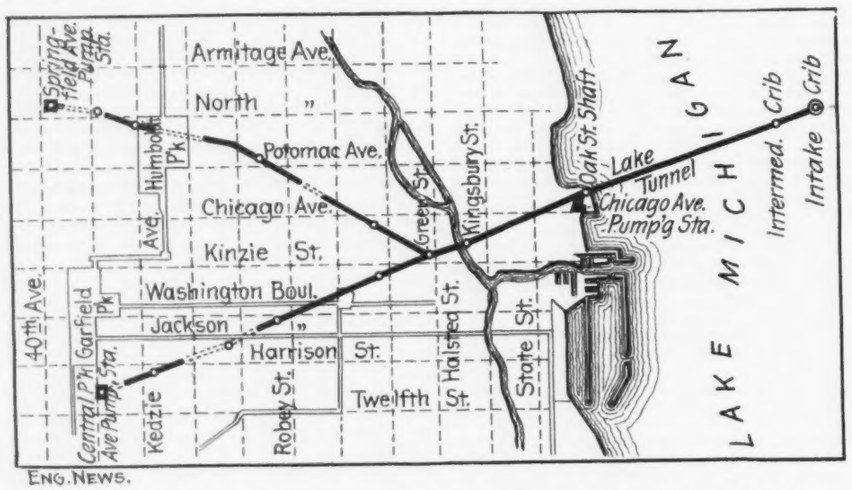
The excavation was carried on by drifts from a temporary shaft in the lake, as well as from the shore shaft at Oak St. The lake shaft was sunk from an intermediate temporary crib, which is the old working crib of the 68th St. tunnel. The FitzSimons & Connell Co., which had the contract for removing this crib after the completion of that tunnel, removed the superstructure and the riprap filling and succeeded in raising the crib. Eight additional courses of timber, 12 × 12 ins., were then added, and on Oct. 25, 1896, the crib was towed out and sunk on the line of the new tunnel, about 2¼ miles from shore, or 1,500 ft. from the permanent crib and intake shaft. This intermediate crib is 70 ft. in diameter with a 30-ft. well. The top of the crib is 12 ft. above datum, or 7 ft. above high water line, and upon it is a two-story superstructure, with rooms for the machinery and the men.

In the well of the crib a cylindrical shaft of ¼-in. steel plates was built up in sections and gradually lowered until it reached the bed of the lake, when it was loaded with a sufficient weight (about 150 tons) to sink it nearly 25 ft. below the bottom of the lake. This steel shaft is 68 ft. deep and 14 ft. 2½ ins. diameter. Some difficulty was experienced in cutting the hole in the timber bottom of the crib to let the steel shaft pass. After ineffectual attempts to seal both the bottom of the crib and the shell, special chisels, weighing 1,800 lbs. each, were used, by which the timbers were cut out. When the steel shaft was completed, it was pumped out and the excavation was carried down to the grade of the tunnel in benches 4 to 6 ft. deep. The brick lining is cylindrical inside, but its exterior forms a series of truncated cones 4 to 6 ft. high, the brickwork of each bench being 17 ins. thick at the base and 20 ins. thick at the top. This shaft will be closed by brickwork conforming to the tunnel section, and the crib and all work above the bed of the lake will be removed.

Intake Shaft.

The intake shaft was sunk through the bottom of the permanent crib, holes 12 ft. 1½ ins. diameter being cut for that purpose after the crib had been set in position. It is built up of cast-iron cylinders 6 to 8 ft. deep, with an outside diameter of 12 ft., as shown in Fig. 3. The cylinders are 2½ ins. thick and have internal flanges for stiffening and for the joints. This iron shaft is 61 ft. deep, the top being 3 ft. above high water line (or 8 ft. above Chicago datum), while the bottom is 16 ft. below the bottom of the lake. Below this iron cylinder the shaft was sunk by underpinning, and putting in brick lining in sections 6 ft. deep, the method of construction being similar to that followed in sinking the intermediate shaft, already described. The brick shaft is 11 ft. in diameter, with a lining of four rings of brickwork. The bottom of the shaft is 99 ft. below datum. The shaft was completed Nov. 15, 1898.

At the top of the shaft will be horizontal handwheels and nuts, engaging with the threaded ends



ENG. NEWS.

FIG. 1.—MAP OF NEW INTAKE SYSTEM FOR THE WATER SUPPLY OF CHICAGO.

of vertical 2½-in. rods attached to three sliding rectangular gates in the iron shaft. Each gate covers a clear opening of 4½ × 6 ft., about 6 ft. below the water line. The gate frames and guides are castings bolted to the outside of the cylinder.

A second intake shaft was put in as soon as the first one was completed, both shafts being alike in dimensions and construction. From this second shaft a stub tunnel 91½ ft. long and 10 ft. diameter was built to connect with the three tunnels

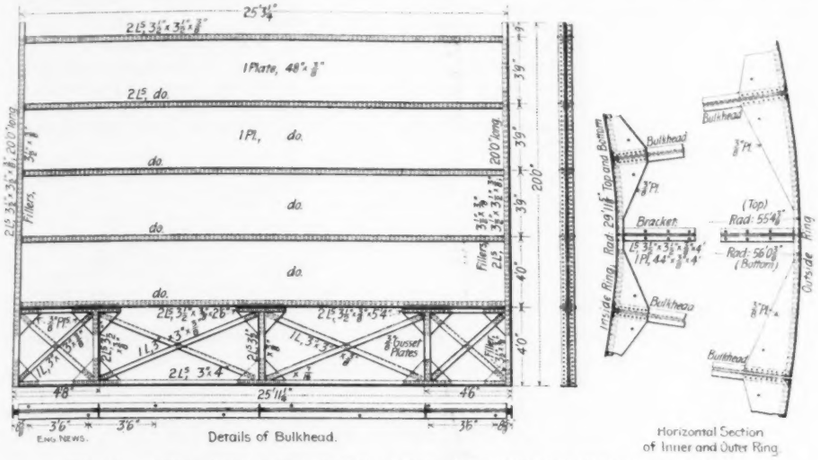


FIG. 6.—STEEL SHELL OF INTAKE CRIB FOR CHICAGO WATER SUPPLY.

which at present take their water from the old two-mile crib. Plans have been prepared for connecting the three two-mile tunnels, and extending them as one tunnel to the second intake shaft in the new crib, thus doing away entirely with the two-mile crib.

Intake Crib.

The caisson which forms the new 2½-mile intake crib for the 10-ft. tunnel is 41 ft. high, 112 ft. diameter at the bottom and 110 ft. 8¾ ins. at the top. Its top is about 17.13 ft. above datum. In it is a circular well 60 ft. diameter, while the entire crib, well and all, has a timber floor 6 ft. thick, through which pass the iron intake shafts already described. The bottom section is 20 ft. high above the base timbers, and is built up of rows of hemlock timbers, 12 × 12 ins., at right angles to one another, and having inside and outside sheathing of vertical planks. The first six rows form the floor across the bottom of the entire structure. Above this floor there are eight rectangular openings or ports 6 × 6 ft., extending through the timber walls, and these ports admit water to the well. In the walls (which are 26 ft. thick) are also formed pockets for loading the structure with concrete to sink it and anchor it in place. The upper section is formed by a steel caisson 20 ft. high, with two concentric shells 25 ft. 4¾ ins. apart, out to out. Vertical radial diaphragms divide the annular chamber between the shells into 24 compartments, which are filled with concrete. Upon this annular crib is built an annular superstructure, with quarters for the men in charge of the intake and lighthouse. The contract for the substructure was let at about $174,380.

The construction of the crib and the base of the superstructure are shown in Fig. 5.

Fig. 6 gives the details of construction of the steel portion of the crib. The shell plates of the inside and outside rings are all ⅝-in. thick, and the bottom course built up of diagonal bracing instead of solid web plates. Midway between the bulkheads (at the base) are vertical triangular brackets riveted to the shells and bolted to the top timbers. The brackets and bulkheads are braced laterally by horizontal gusset plates, which are also bolted to the timbers, thus effecting a secure connection between the timber and steel sections of the crib. Fig. 7 is a part plan of this steel section. The shop rivets are of steel, and the field rivets of wrought iron. All the rivets are ¾-in. diameter, with a pitch of 2½ ins.

The crib was commenced July 28, 1896, and was launched on Aug. 19, being then about seven timber courses in height. The wooden section was completed in September, when work was stopped for a time. The steel portion was commenced Dec. 18, 1896, and completed about March 8, 1897. On Aug. 12, 1897, the great structure, weighing about 8,500 tons and drawing about 28 ft. of water, was towed out to the site marked by buoys. It was successfully sunk by pumping water into the central well, and after being settled into position (penetrating about 2 ft. into the bed of the lake) riprap stone was dumped around the outside. The concrete filling of the compartments was also at once commenced. The depth of water at the side is 35 ft., and the inlet ports to the well are 6 ft. above the bottom. It is expected that at this depth there will be much less trouble with ice than at the present cribs, where the ports are near the surface. The gates of the intake shaft within the well are about 6 ft. below the surface of the water.

The Assistant City Engineer, Mr. John H. Spengler, has general supervision of all tunnel and crib construction. The engineers in charge of the work on the crib were Mr. E. W. Jackson and Mr. H. H. Jackman. The other engineers engaged on the design and construction of the crib were Mr. A. G. Riter, Mr. Paul G. Brown and Mr. Thos. G. Pihlfeldt.

On top of the crib will be a masonry superstructure, with a house for the cribkeepers and lighthouse men, there being a steel tower 40 ft. high, surmounted by a lantern. This superstructure is of annular form, surrounding the well. It is mainly of concrete, faced with ashlar masonry on the outer side, and with enameled brick on the inner side. The building is of buff pressed brick, approximately semicircular in plan, the rest of the crib forming a semicircular promenade. The diameter of the well is 60 ft. 4 ins., and of the outside of the building 105 ft., the inside width of the rooms being 18 ft. 6¼ ins. Fig. 8 is a plan of the basement floor of the crib, and Fig. 9 is a plan of the main floor.

The rooms on the surface of the crib are the bunk room, kitchen, two dining-rooms (one on each side of the kitchen), two bed-rooms, bath-room and reception-room. The floors are of brick arches between I-beams, laid radially. In the basement are provision, ice and coal rooms, engine and boiler-room, machine shop, and a circular lamp-room 12 ft. in diameter. The basement floor is 13.05 ft. above datum. It is formed in the concrete filling between the two concentric shells of the crib, and on the inside of the well, at this level, is a circular gallery 5 ft. wide supported by brackets. A cross-section of the annular wall of the crib (with end elevation of the building) is shown in Fig. 10.

On the first or basement floor, the inner circumference of the well is faced with white enameled brick (costing not less than $70 per 1,000), and the same brick is used for the main entrance hall on this floor. The floors and stair will be finished off with a granolithic top dressing 1½ ins. thick. For the second floor, or the building proper, the outer and end walls are of buff hydraulic pressed brick ($23 per 1,000), backed with hard-burned sewer brick, and the walls have coping tiles to match the roofing tiles. The inner wall is faced with white enameled brick. Above the brick floor arches is a concrete filling, covered with two layers of roofing felt, upon which are 1¼-in. maple floor planks, blind-nailed to strips embedded in the concrete. The brick smokestack will extend 26 ft. above the eaves of the roof. All stone work for trimmings, etc., is of buff Bedford building stone.

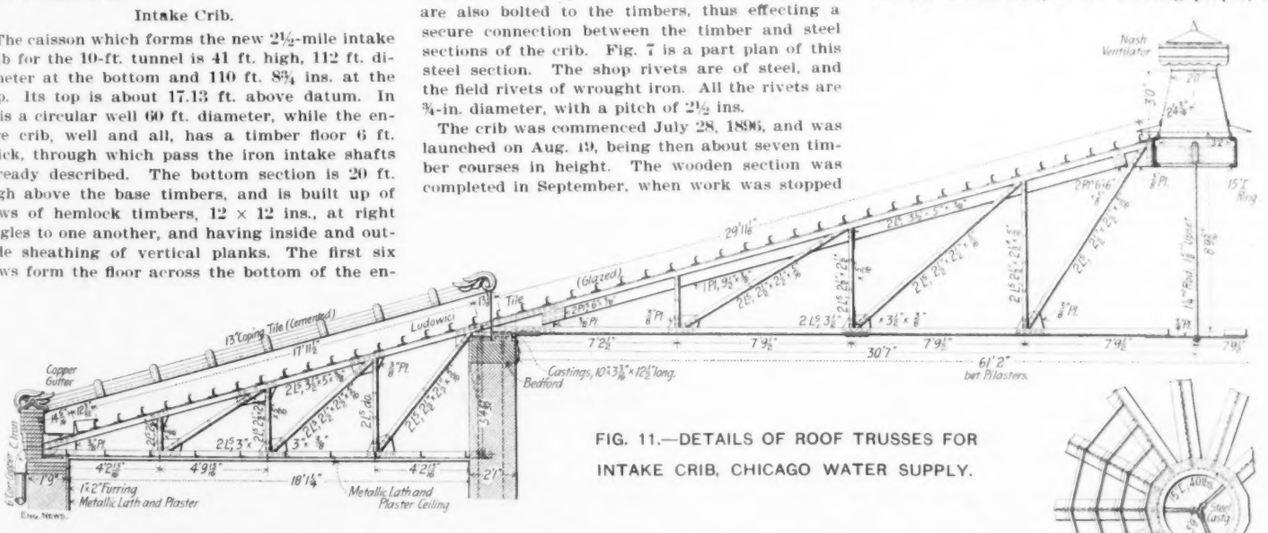


FIG. 11.—DETAILS OF ROOF TRUSSES FOR INTAKE CRIB, CHICAGO WATER SUPPLY.

Over the well is a conical roof, 61 ft. 2 ins. diameter, with a rise of 8 ft. 9 5-16 ins., supported by 13 radial trusses 30 ft. 7 ins. long. It is covered partly by glazed tiles and partly by glass tiles. At the center is a Nash ventilator. The tile roof of the segmental building is supported by eleven

trusses, placed radially between the inner and outer walls. The horizontal bottom chords of these trusses are connected by angle irons ¼ × 2½ × 3 ins., supporting metallic lath for a plaster ceiling. These trusses are shown in Fig. 11.

Steam for heating purposes will be supplied by two horizontal tubular boilers, 48 ins. diameter and 16 ft. long, each containing 30 tubes 4 ins. diameter and 16 ft. long. In the boiler-room there will be two duplex pumps 5¼ × 3½ × 5 ins. For electric lighting there will be a 9-HP. gasoline engine, driving, by means of a belt, a multipolar, direct-current, compound-wound dynamo of 75 lights capacity. The dynamo will have a capacity of about 5-K-W. at 125 volts, and its speed must not exceed 850 revolutions per minute. A small electric pump will supply water to the tank above the bunk-room. In addition to the incandescent lamps there will be two 150-hour arc lamps, with hoisting rigs. One of these will be in the well near the shaft, and the other in the lighthouse.

The lighthouse tower will be an octagonal framework, about 17 ft. diameter at the bottom and 7 ft. at the top, where it is surrounded by a platform 3 ft. 9 ins. wide. The height is 40 ft. to the platform or base of the lantern. It will have eight legs, each composed of two angle irons forming a T-column, and in the center will be a vertical iron tube 25 ins. in diameter, through which the lamp will be hoisted and lowered.

The contract for the superstructure was let at about $35,000.

Land Tunnel.

As already noted, the 10-ft. lake tunnel will connect with a land tunnel forming a Y, a new pumping station being located at the end of each of the two arms.

Section 1.—This section of the land tunnel, extending from Oak St. southwest to Green St., is 10 ft. diameter and 8,666 ft. long. The contract was awarded Sept. 30, 1895, to the FitzSimons & Connell Co., of Chicago, and the work was completed in April, 1897. There was an intermediate shaft at Kingsbury St., 6,250 ft. west of Oak St., this being 12 ft. diameter. The shaft at Green St. is 10 to 12 ft. diameter and 99.2 ft. deep. This section of the work was entirely in a hard gravelly clay (in some places resembling hardpan), with the exception of one quicksand pocket and some small sand and gas pockets. Dynamite was used continually on account of the compact and tough character of the clay, and an excavating machine was tried, but proved unsatisfactory. Mr. J. H. Spengler, Assistant Engineer, was in charge of this section from its commencement to its completion, with Mr. Edwin Woods as sub-assistant.

Section 2.—This is a continuation of Section No. 1, extending southeast from Green St. to a new pumping station at Central Park Ave and Fillmore St. It is 8 ft. in diameter and 3.76 miles in length, of which 9,962 ft. are in solid rock, 9,391 ft. in earth and 503 ft. partly in earth and partly in rock. There are four intermediate working shafts. The Central Park Ave. shaft is 105 ft. in depth, 59 ft. being in earth and 46 ft. in solid rock. Work was commenced in 1895, but has been at a standstill since October, 1897, owing to litigation between the city and the contractors in regard to certain payments. About 14,602 ft. of tunnel have been excavated and partly lined. Mr. F. G. Ewald was in charge of the section until September, 1896, when he was succeeded by Mr. C. T. Anderson. In April, 1897, the latter resigned, and Mr. Ewald again took charge, with Mr. N. A. Sager as assistant. The contract for the work was awarded to Mr. Joseph Duffy, of Chicago, on Sept. 30, 1895, and work was commenced on Nov. 23 of the same year.

Section No. 3.—This section extends northwest from the Green St. shaft to the new pumping station at Springfield Ave. and Bloomingdale Road, a total distance of 4.2 miles. It is 8 ft. in diameter, and work has been prosecuted from four intermediate shafts. Mr. E. W. Jackson was first engineer in charge of this section, but in 1896 he was transferred to the new lake tunnel, and Mr. John H. Spengler was then in charge until July, 1897, when he was succeeded by Mr. D. J. Barnes. In September, 1897, Mr. W. D. Barber was put in charge of this section, and he in turn was succeeded by Mr. G. F. Samuel in August, 1898. The contract was awarded to Weir, McKechney & Co., of Chicago, on Oct. 19, 1895.

The work on Section No. 3 has been delayed considerably by litigation between the city and the contractors. In April, 1898, the latter stopped work, as the result of a controversy with the city authorities as to the way in which the work was being prosecuted. In May, 1898, the pumps were withdrawn and the tunnel was allowed to fill with water. In July, an agreement was arrived at, by which work was to be resumed under the former arrangements, leaving the questions at issue to be decided by the courts. Work was recommenced in August, but in November the contractors, without giving notice to the city, obtained an injunction to restrain the city from interfering with their work and from taking possession of the tunnel and plant. They at once stopped work, withdrew the pumps, and allowed the tunnel to fill with water. Work has not been resumed.

The city claims that the work has been done recklessly and with excessive excavation. Mr. Thomas T. Johnston, M. Am. Soc. C. E., examined the work in November, 1898, on behalf of the city, and stated in his affidavit that the excavations were unnecessarily large. In earth they were 200% in excess of the tunnel diameter, while they need not have been more than 20% in excess. In drift No. 5 he found that the excavation extended over 20 ft. above the center line of the tunnel, endangering the lives of the men, and tending to cause undermining of buildings, etc. The Supreme Court dissolved the injunction in June, 1899, and the city now intends to carry on the work for itself.

At the end of 1898 the condition of the work on the lake tunnel and the several sections of the land tunnel were as shown in the following table, and there has been little, if any, change since then:

	Tunnels.			
	Land			
	Sec. 1.	Sec. 2.	Sec. 3.	Lake.
No. of shafts	3	5	5	3
Total length	8,666	19,856.2	22,177.0	14,033
Length completed	8,666	9,898.3	17,532.5	14,033
Excavated, but not lined		4,703.4	2,675.8	...
Unfinished		5,254.5	1,974.7	...

Connecting Tunnel.

A tunnel 960 ft. in length and 7 ft. in diameter has been built from the old Chicago Ave. pumping station northeast to a connection with the new land tunnel, at a point 420 ft. west of the Oak St.

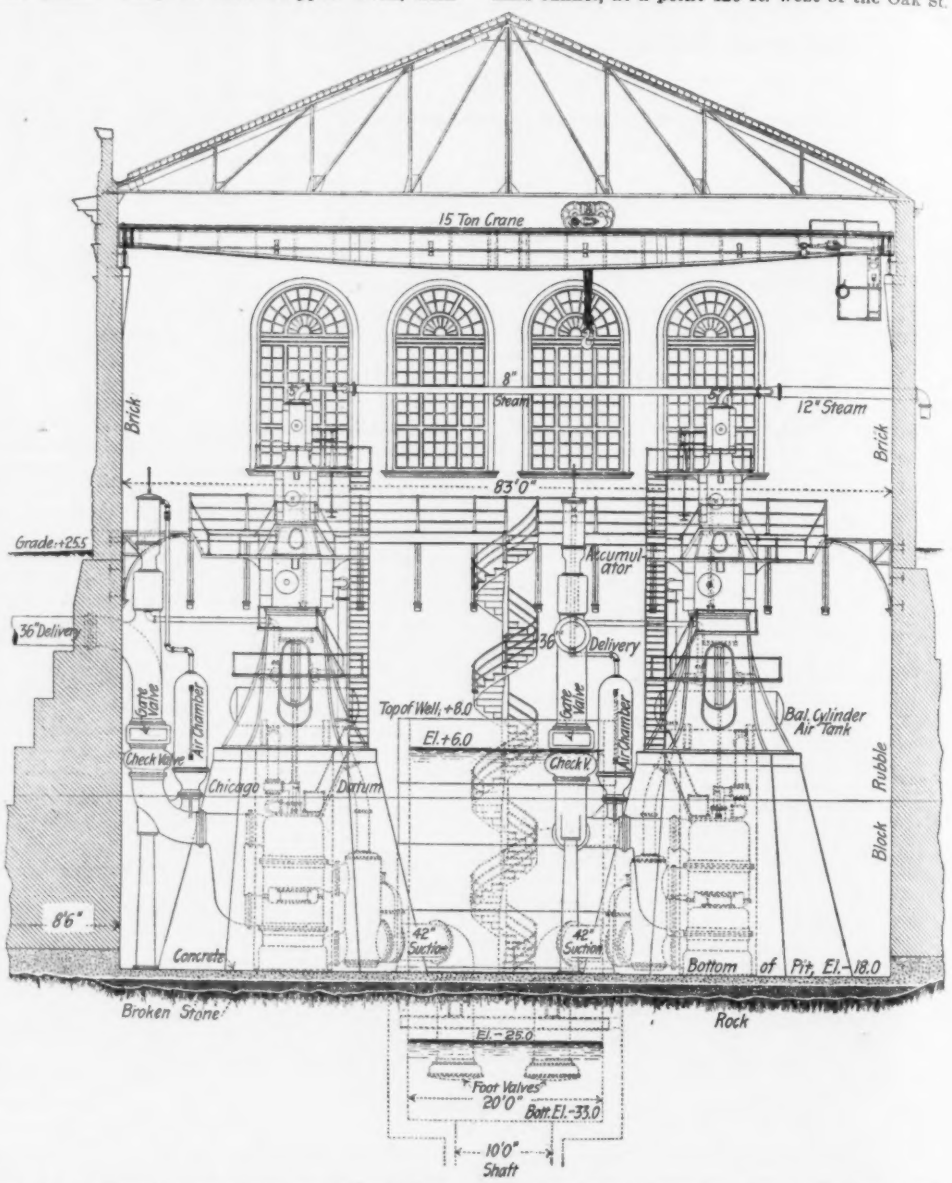


FIG. 12.—VERTICAL SECTION OF SPRINGFIELD AVE. PUMPING STATION FOR THE CHICAGO WATER SUPPLY.

shaft. From the south end of this tunnel, at Pearson St., a 6-ft. tunnel, 520 ft. long, runs west under Pearson St. and round to the Boulevard side of the station, where a new pumping engine will be erected. A 5-ft. tunnel, 127 ft. long, also carries the main tunnel on to the old 7-ft. lake tunnel. All this work was done by city labor. Exceptionally good progress was made, averaging 20.4 ft. per working day on the 7-ft. tunnel, although but little dynamite was used. The cost was at a minimum, considering the fact that the wages paid by the city to the various classes of labor employed averaged 40% higher than those paid by contractors for the same class of work. This tunnel was built under the direction of Mr.

Paul G. Brown, Assistant Engineer, assisted by Mr. E. P. Scott.

This connection is designed to be used to relieve the two-mile tunnels by furnishing water, in case of emergency, by way of the new 10-ft. tunnel to the pumps at the Chicago Ave. pumping station. It will also serve, incidentally, to lower the head pumped against at the Central, West and Fourteenth St. stations. If necessary, the new lake tunnel can supply at least half of the capacity of the Chicago Ave. station, in addition to what is required by the new pumping stations at Central Park Ave. and Springfield Ave. Plans for the installation of modern engines in this station and the remodeling of the tunnel system at this point are now under consideration.

Pumping Stations.

We have already explained that the two branches of the land tunnel will each supply a new pumping station. These stations were designed by Mr. Henry Sierks, City Architect, and the contract for their construction was awarded in 1897 to Mr. John P. Agnew, of Chicago. Each station will have four vertical pumping engines of 20,000,000 gallons capacity, and in 1897 contracts were awarded to Henry R. Worthington, New York, for three engines at each station. The engines will have 42-in. suction pipes in the wet wells, and 36-in. discharge pipes.

Central Park Ave. Station.—Work was commenced Oct. 5, 1897, and by April, 1898, the entire area of the pump-pit had been excavated to a depth of 4 ft. below datum. The first part of the work was done by scrapers and teams, after which boom-derricks and skips were used. Below this the work was done by excavating trenches for the retaining walls, the core being removed after the walls were well advanced. The building is now nearly completed. Mr. F. G. Ewald was the engineer in charge in 1897, but was succeeded by Mr. C. L. Crabbs, who is assisted by Mr. Iver Horgen.

Springfield Ave. Station.—This station will be 85 × 100 ft. inside the pump-room, and in the center will be an oval wet well 25 ft. deep, having a steel shell lined with 13 ins. of brick. A 10-ft. shaft will extend from the well down to the tunnel. The bottom of the well will be 33 ft. below datum, or 38 ft. below high-water level, while the bottom of the pump pit will be 18 ft. below datum. The top of the well will be 8 ft. above datum. The station is shown in section in Fig. 12, and will be completed during the present year. Mr. F. G. Ewald was the engineer in charge until October, 1898, when he resigned and was succeeded by Mr. G. F. Samuel, who is now in charge.

RICH MINERAL DISCOVERIES are reported by the contractors for the Columbia & Western Ry., which the Canadian Pacific Ry. is building from Rossland into the Boundary Creek district of British Columbia. It is stated in the press dispatches that the ledges of ore running high in copper, gold and silver were uncovered during the grading operations for the new road, and that the contractors, McKenzie & Mann, have filed claims on the property. Assays from near the surface of the ledge are stated to have given values of from $40 to $50 per ton.

CIVIL SERVICE EXAMINATIONS for positions in the Department of Public Works of the city of New York will be held as follows: Sept. 2, for superintendent of sewage disposal works at Far Rockaway; Sept. 5, for foreman department of street cleaning; Sept. 7, district superintendent, department of street cleaning; Sept. 8, topographical draftsman. The examinations will be held at the offices of the Municipal Civil Service Commission, New York city.

THREE-CYLINDER COMPOUND LOCOMOTIVES with eight wheels, all coupled, are now being used extensively for freight service on the London & Northwestern Ry. (England). The compounding is on the system designed by Mr. F. W. Webb, the Chief Mechanical Engineer, but all the cylinders drive one axle, while in the passenger engines they drive two axles. The freight engines have outside inclined high-pressure cylinders, 15 × 24 ins., and the low-pressure is 30 × 24 ins., placed under the smokebox. The driving wheels are 4 ft. 5½ ins. diameter, with a wheelbase of 17 ft. 3 ins., and the second pair are the main drivers. The boiler has 1,489 sq. ft. of heating surface and 20½ sq. ft. of grate surface, and carries a working pressure of 175 lbs. per sq. in. The total weight is 110,300 lbs., with 32,256 lbs. on the main driving axle.

FOUR-CYLINDER COMPOUND LOCOMOTIVES of the eight-wheel and ten-wheel types are being adopted on several French railways for fast passenger service. Some of the eight-wheel engines for the Eastern Ry. have the peculiar double-barrel Flamand boiler, the lower barrel being 3.8 ft. diameter and filled with water, while the upper barrel is 2.6 ft. diameter and forms the steam space. The high-pressure cylinders are outside, close to the forward drivers, and are connected to the rear drivers. The valve gear for these cylinders is outside the connecting rods, and the valves are on top of the cylinder but with inclined seats. The low-pressure cylinders are inside, and drive the front driving axle. The Westinghouse air-brake pump is placed under the running board, between the truck wheels. The engines weigh 125,000 lbs., with 74,000 lbs. on the drivers.

A NEW FORM OF DUMP CAR was recently exhibited in the yards of the Chicago & Eastern Illinois R. R., at Chicago. It has the peculiarity of being a level-floor or "hopperless" dump car, for carrying coal, ore, gravel, etc., in general railway service, and can be unloaded by shoveling if desired. It resembles an ordinary gondola car, with the side planks astride the stakes, and with a beveled timber to fill the bottom corners and prevent the lodgment of material. In the floor of the car are 16 hinged trap doors, in two rows of eight doors, the hinges being lengthwise of the car. Rods with locking catches run half the length of the car, and are operated by levers on the end sills. The doors are thus operated in four groups, so that the load can be partially dumped, and the objections to long rods (which may buckle and become hard to move) are obviated. The doors are operated by chains running in grooves in the timbers forming the sides of the openings, the chains being attached to longitudinal rods or shafts terminating in crank handles under the end sills. With the car ready to dump, the pawls are disengaged from the ratchet wheels on the chain shafts, and the locking rods are revolved by the levers (together or separately), thus withdrawing the latches and allowing the doors to fall. The chain shafts are then revolved, winding up the chains and raising the doors until they are automatically locked by the latches on the locking rods. When the doors are closed, there is no load upon the operating chains. The car is the invention of Mr. W. A. Caswell, and was built by the Georgia Car & Mfg. Co., of Savannah, Ga., for the Caswell Car & Improvement Co., Marquette Building, Chicago, Ill.

A TIE-PRESERVING PLANT for the Burlington & Missouri River R. R. is now being built at Edgemont, So. Dak., under the direction of Mr. Samuel M. Rowe, M. Am. Soc. C. E., of the firm of Rowe & Rowe, Consulting Engineers, 226 La Salle St., Chicago. It is to be of sufficient capacity to treat about 50,000 ties per month, the timber being principally mountain pine from South Dakota and Montana. It is believed that this timber will take the treatment equally as well as the pines from Colorado and New Mexico. It is intended to use the simple burnettizing process (chloride of zinc), as the country where the ties are to be used is practically rainless, so that an auxiliary treatment to prevent the preservative from leaching out is not considered necessary. The plant is, however, being so arranged that it can treat by the zinc-tannin or Wellhouse process in the future, if so desired.

AUTOMATIC COUPLERS AND TRAIN BRAKES have been applied to over 60% of the freight cars in the United States, according to the last semi-annual report of the Interstate Commerce Commission covering the progress made up to June 1, 1899. The report shows the advancement made between Dec. 31, 1898, and June 1, 1899. Of the 294 railway companies that have been granted two years' additional time in which to perfect their equipment 31 roads were merged in other companies and one road failed to make return to the Commission. This leaves 262 roads that reported an aggregate of 1,251,415 freight cars and 34,787 locomotives owned June 1, 1899. Of the freight cars, 113,233 were reported as having been equipped with automatic couplers and 79,554 with train brakes during the six months ending June 1, which brings the total so equipped up to 1,040,147, or 63% of the freight cars equipped with automatic couplers, and 698,719, or 56%, equipped with train brakes. Of the 34,787 locomotives owned on June 1, 32,426, or 93%, are equipped with driving-wheel brakes. There are 211,268 freight cars out of a total of 1,251,415, or 17%, that are not equipped with automatic couplers; 552,696, or 44%, that are unequipped with train brakes, and 2,361, or 7%, of the locomotives not equipped with driving-wheel brakes to June 1 last.

THE TEST OF BRAKES for street railway cars, conducted by the New York State Railroad Commission, was begun on Aug. 29 on the Lenox Ave. line of the Metropolitan Street Railway Co. of New York city, when the electric brake of the General Electric Co., Schenectady, N. Y., and the hand brake of the Devlin Street Car Brake Co., of Memphis, Tenn., were tested. The test consisted in making emergency and service stops while running at 8, 12, 16 and 18 miles per hour. An automatic device, invented by Mr. Chas. R. Barnes, Electrician to the Commission, records the distance passed over and the time of the stop. Tests of other brakes are to be made at future dates, which will be announced.

THE NATIONAL EXPORT EXPOSITION, which opens at Philadelphia on Sept. 14, and continues until Nov. 30, promises to be as successful as it is unique in the commercial history of the United States. On the 56 acres of land deeded to the Philadelphia Museums of Commerce by the city, there have been built a number of handsome exhibition buildings and the United States government and United States and European manufacturers have contributed exhibits of almost every variety of goods suitable for foreign trade. The exposition will be held under the authority of Congress, and is endorsed by the principal chambers of commerce, boards of trade and other commercial organizations of the country. One of the features of the exposition will be an International Commercial Congress, which will be convened on Oct. 10, 1899. The general subjects to be discussed are: Foreign trade in general; parcels post; interoceanic canal; international banking and currency; our new spheres of influence, and the West Indian, Latin American, Asiatic, Australian, South African and European sections in connection with their commercial relations with the United States. These subjects will be treated by some of the ablest European representatives, as well as by Americans who have studied the problems involved. Over thirty foreign governments and chambers of commerce have appointed representatives and commissioners to attend this Congress.

THE TOLEDO CENTENNIAL EXPOSITION GROUNDS at Bay View Park, are rapidly being prepared. About 2,000 piles have been driven out of a total of about 4,000 in the entire work. Construction has begun on a large dock and dredging for the lagoon will soon follow. Bick & Hussey are the contractors, and Mr. W. J. Sherman is Chief Engineer.

THE HOLLAND SUBMARINE TORPEDO BOAT was again tested near Shelter Island on Aug. 19. The run was over the government course at this place, and was made both awash and submerged. It is said that the speed while submerged was 7½ miles per hour; in this trial she disappeared in less than 5 seconds, and made the run on an ever keel about 6 ft. below the surface. When about 4 ft. below the surface she discharged a dummy Whitehead torpedo, of the smaller U. S. navy type, which weighs 820 lbs. and carries 110 lbs. of guncotton. The torpedo was projected about 75 ft. in a straight line by the air pressure; there was very little disturbance on the surface from the discharge of the torpedo.

SMOKELESS FIRING WITH BITUMINOUS COAL ON PASSENGER LOCOMOTIVES.

Much has been heard lately as to the possibility of smokeless firing on passenger locomotives, in order to avoid the great nuisance from smoke and cinders entering the cars, and also to effect some economy in coal consumption without impairing the efficiency of the engine or reducing its performance. Several roads are now introducing the "continuous firing" system with this object in view, while the Cincinnati, New Orleans & Texas Pacific Ry. has equipped some of its engines with a device for improving the combustion and so preventing the emission of smoke.

A brick arch is placed in the firebox, the lower end being just below the bottom of the boiler barrel, while the upper end is above the level of the top of the fire door. This is supported on four inclined water tubes which enter the front water leg and the space above the crown sheet. Through the arch itself run four 2¼-in. tubes, whose lower ends are fitted into 2½-in. tubes which extend across the water leg, and are open to the atmosphere, while the upper ends are open to the firebox and flattened to form an elongated opening. On each side of the firebox, 12 ins. above the level of the grate, are four 2-in. tubes open to the atmosphere. These are fitted with Sharp's patent deflecting air tubes, which deflect the air upon the fire. The air passing through the arch tubes is heated to a high degree, and by supplying oxygen to the unconsumed gases as they pass over the upper edge of the arch, it helps to produce complete combustion.

The fuel is screened lump coal of good quality, and the following instructions are issued to the enginemen and firemen in order to educate them so that they may so work as to produce the desired results:

Explanatory.—Bituminous coal contains a large percent-

age of hydrocarbons, which are nearly all driven off as gas by the heat of the furnace, in a few seconds after the coal enters the firebox.

Hydrocarbons, when unconsumed, make objectionable black smoke, but when a sufficient quantity of air is mixed with the hydrocarbons, combustion is complete, and no smoke appears.

Passenger locomotives have been provided with hollow fire-brick arches and deflecting air tubes to deflect the gases and to supply the necessary air to make perfect combustion.

Rules.—After firing each shovelful of coal, the door must be left open one or two inches for a few seconds, admitting enough air to produce complete combustion of the gases driven off from the coal. Care must be taken not to leave the door open longer than necessary to consume the gases.

Firemen must learn to work as light a fire as possible. Great care must be taken that the steam is not wasted at the safety valve, either when the train is in motion or when standing still.

Before starting, the blower must be put on and a sufficient supply of coal put into the firebox to insure a good solid fire. After the coal has been put in, the door must be left partly open by placing the latch on the first notch of the catch, to so remain until the smoke entirely disappears, when the door must be closed.

After starting, the door must be left partly open after each shovelful of coal is put into the firebox, by placing the latch on the first notch of the catch until such time as the smoke disappears, when the door must be closed.

On approaching tunnels, the fire must be replenished in ample time, obtaining sufficient fire to carry the train through the tunnel without smoke, the door to be kept closed while passing tunnels.

The engineman should so arrange the water supply that the fireman may be able to fire the engine regularly and economically, and this can be done best when the water is supplied to the boiler continuously.

Firemen must pay particular attention to the manner in which the engineman works the injector and handles the engine, in order to regulate the fire accordingly.

Care must be taken to have the blower applied and the door partly open when approaching a station where stop is to be made, and no smoke must be allowed to show from the stack at such times or when descending grades.

While the blower is being used, except when approaching a station where stop is to be made, care should be taken to keep the door closed as much as possible, more especially when cleaning the fire, as the blower causes the cold air to be drawn into the flues.

While lying on side tracks, both dampers should be closed to save the fire.

Grates should be shaken only when absolutely necessary, as too frequent shaking causes a loss of fuel by allowing the unconsumed coal to fall into the ash-pan, where it ignites and causes the pan to heat and warp. Ash-pans should be examined as frequently as stops will permit, and under no circumstances must they be allowed to become filled.

When possible to avoid it, the fire-door must not be left wide open. To leave the fire door wide open is especially bad when using steam or blower.

It is beneficial to wet the coal before firing, and firemen should, as far as possible, use wet coal.

Intelligent firing and economical results in the use of fuel will be considered in the selection of firemen for passenger engines, or for promotion to freight firemen.

These rules must be strictly observed on night as well as on day passenger trains.

It was found that constant vigilance was necessary to secure continuous good results, as some of the men grew careless and dropped back to the old way of firing several shovels of coal at a time. For the purpose of keeping a close check on all passenger engines, small report blanks were distributed to passenger and freight agents, roadmasters and supervisors, signalmen, etc., and when they observe smoke on passenger trains it is their duty to report the matter by filling out the blank and forwarding it to the Superintendent, who promptly investigates the matter. If it is due to poor coal, as in most instances, a better quality is supplied, or if it is careless firing, the party responsible is disciplined.

FIG. 1.—60,000-LB. GONDOLA CAR WITH STEEL UNDER-FRAME FOR THE IMPERIAL CHINESE RYS., BUILT BY THE BLOOMSBURG CAR MFG. CO., BLOOMSBURG, PA.

For the above particulars we are indebted to Mr. W. J. Murphy, Superintendent of the Cincinnati Division of the C., N. O. & T. P. Ry., Lexington, Ky., who has sent us photographs showing the results of the new system. One of these shows the Queen and Crescent Limited express train, with eight cars, ascending a grade of 26 ft. per mile, at a speed of 40 miles per hour. The other shows the same train, with five cars, ascending a grade of 52 ft. per mile at 61 miles per hour. The speeds were taken from the speed-recorders on the engines, and the views show an entire absence of the heavy black smoke which is so objectionable.

FREIGHT CARS FOR THE IMPERIAL CHINESE RAILWAYS.

The gondola car shown in the accompanying cut is not part of the rolling stock of the Illinois Central R. R., notwithstanding the legend on its side. The letters "I. C. R." stand for "Imperial Chinese Railways," and the car is one of a lot which are now being built for shipment to the Celestial Kingdom by the Bloomsburg Car Manufacturing Co., of Bloomsburg, Pa. The cars are of 60,000 lbs. capacity, and 4 ft. 8½ ins. gage. They are 33 ft. 4 ins. long over end sills, and 8 ft. 4 ins. wide out to out of side sills, and their total weight is about 26,000 lbs. The floor inside measures 8 × 33 ft. in the clear. The top of the floor is 4 ft. 2 ins. above the rail, and the center line of the Janney draw-bar is 3 ft. 7 ins. above the rail, or 8 ins. higher than the United States standard. This brings the coupler directly in line with the car sills. The coupler differs from the regular M. C. B. standard in having a solid knuckle, no slot being left for the link. This looks as if far distant China was likely to get ahead of the United States in this detail of M. C. B. coupler practice.

The car has a steel underframe consisting of 10-in., 22-lb. steel channels, and the floor is further strengthened by four truss rods. The truck used with these cars is the "Black Diamond" steel truck, which was described in connection with a general article on steel trucks in our issue of Sept. 15, 1898. A view of the truck is shown in Fig. 2. The principal member used in its construction is a 5 × 3½-in. T-section, which is also used in the construction of the "Black Diamond" body bolster with which the car is equipped. Both the truck and the bolster are made by the Bloomsburg Car Mfg. Co., and were specified by the engineers for the Chinese railways after careful examination of the drawings and specifications. The truck frame complete, without brake forgings, weighs 1,600 lbs.

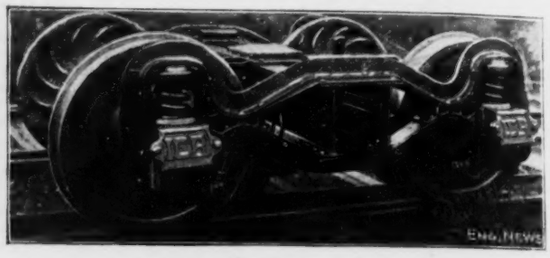


FIG. 2.—"BLACK DIAMOND" TRUCK USED ON CARS FOR IMPERIAL CHINESE RAILWAYS.

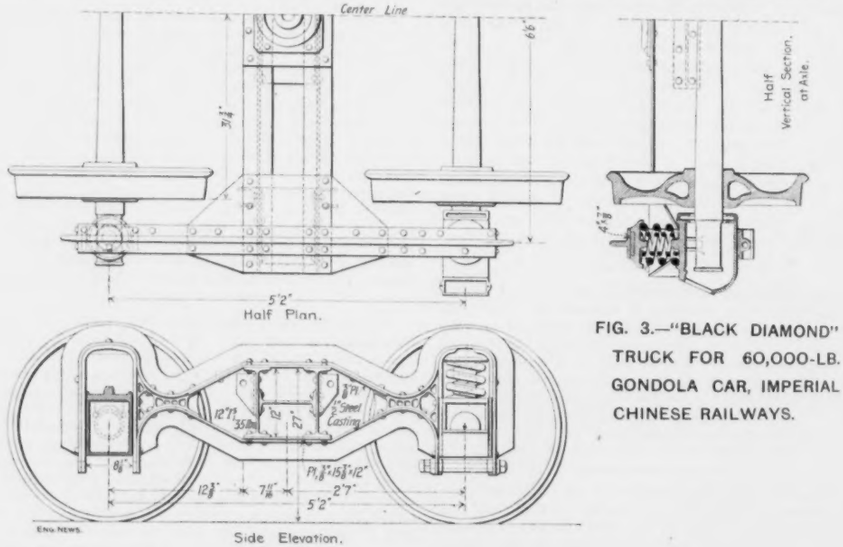


FIG. 3.—"BLACK DIAMOND" TRUCK FOR 60,000-LB. GONDOLA CAR, IMPERIAL CHINESE RAILWAYS.

The axles are of open-hearth steel with journal centers, 6 ft. 6 ins. apart, instead of the 6 ft. 3 ins. of the M. C. B. standard. The wheels are Griffin chilled wheels, balanced and ground.

These cars are assembled at the works and then knocked down and packed for shipment to their destination, a journey half-way round the globe. They will be assembled and finally riveted up at New Chwang, China.

We are indebted to the courtesy of Mr. W. P. Meigs, Secretary of the Bloomsburg Car Mfg. Co., for the information from which this description has been prepared.